The Implementation of assimilation cycle in COSMO model at IMS:

Achievements and problems

P. Khain, A. Shtivelman, H. Muskatel, I. Carmona, Y. Levi, S. Krichak

Israel Meteorological Service

COSMO User Seminar, Offenbach
March 2015

Outline

1. **Israel Met. Service (IMS) involvement in COSMO projects**
   a. **RC^2** **(0.8 FTE)**
   b. **CALMO** **(0.65 FTE)**
   c. **Single precision assimilation (POMPA)** **(0.25 FTE)**
   d. **XML implementation (VERSUS)** **(0.15 FTE)**
   e. **Terra Stand-Alone consolidation** **(0.15 FTE)**

2. **COSMO model at IMS**
   a. **From “Cold” to “Warm” starts, achievements**
   b. **Problems …**
      - Too low humidity at stable stratification
      - Underestimation of light rain in COSMO 2.8km
      - Insufficient penetration of precipitation from sea to land in COSMO 7km

3. **Conclusions**

Outline

1. Israel Met. Service (IMS) involvement in COSMO projects
   a. RC^2 (0.8 FTE)
   b. CALMO (0.65 FTE)
   c. Single precision assimilation (POMPA) (0.25 FTE)
   d. XML implementation (VERSUS) (0.15 FTE)
   e. Terra Stand-Alone consolidation (0.15 FTE)
2. COSMO model at IMS
   a. From “Cold” to “Warm” starts, achievements
   b. Problems …
      - Too low humidity at stable stratification
      - Underestimation of light rain in COSMO 2.8km
      - Insufficient penetration of precipitation from sea to land in COSMO 7km
3. Conclusions

1a. Revised Cloud Radiation Coupling – RC²

[Uli Blahak, Harel Muskatel, Pavel Khain]

Overview (major points):

- Revising the parametrization of the optical properties of cloud droplets and ice
- Adding parametrization for optical properties of rain drops, snow and graupel

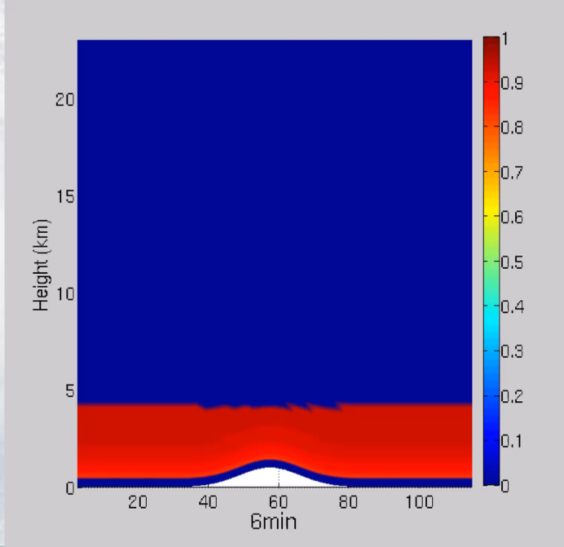
Already implemented by Uli Blahak in COSMO (still not official)

IMS modest contribution

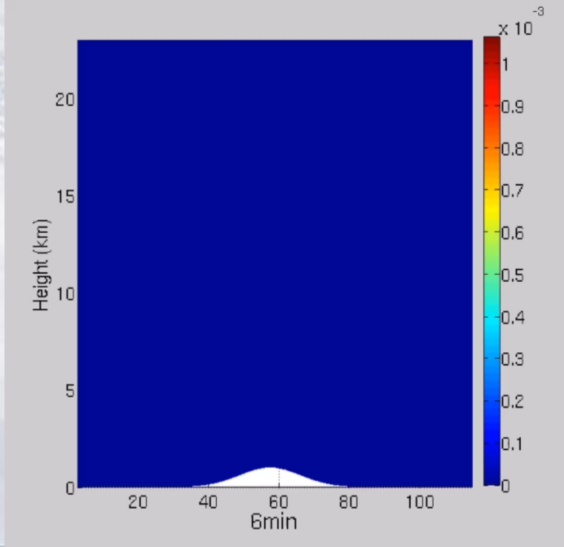
1. Updating already existing parametrization of optical properties of snow and graupel
2. Sensitivity tests to reduce the number of tuning parameters of the new radiation scheme

Idealized COSMO Version
A tool for sensitivity tests and processes learning (by Uli Blahak)

Cloud cover
Example: CB clouds in tropics



Snow content **(kg/kg)**
not seen by the previous radiation scheme



Outline

1. Israel Met. Service (IMS) involvement in COSMO projects
   a. RC^2 (0.8 FTE)
   b. CALMO (0.65 FTE)
   c. Single precision assimilation (POMPA) (0.25 FTE)
   d. XML implementation (VERSUS) (0.15 FTE)
   e. Terra Stand-Alone consolidation (0.15 FTE)
2. COSMO model at IMS
   a. From “Cold” to “Warm” starts, achievements
   b. Problems …
      - Too low humidity at stable stratification
      - Underestimation of light rain in COSMO 2.8km
      - Insufficient penetration of precipitation from sea to land in COSMO 7km
3. Conclusions

1b. CALMO Priority Project

A. Voudouri[1], P. Khain[2], JM. Bettems[3], I. Carmona[2], E. Avgoustoglou[1], F. Grazzini[4]
Thanks to: O. Bellprat[5], G. de Morsier[3], O. Fuhrer[3], M. Arpagaus[3], P. Kaufmann[3], Y. Levi[2], A. Shtivelman[2], Y. Yosef[2], J. Toedter[6], I. Cerenzia[7]
(1) HNMS, (2) IMS, (3) MeteoSwiss, (4) ARPA-SIMC, (5) IC3, (6) GUF, (7) ARPA-EMR

Idea

Calibration of model parameters

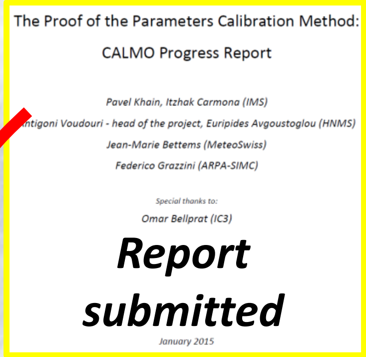
Calibration ***method*** was developed by Bellprat et al. (2012) using climate model CCLM-4.8

Goal

Apply the calibration *method* for NWP COSMO

Stage 1 - Apply to COSMO-6.6km

(based on 3 parameters, Switzerland area and 40-days validation period)

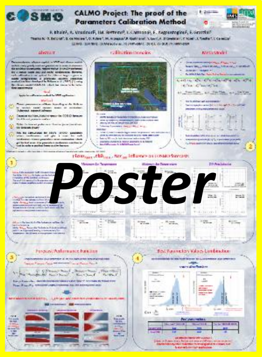

The Proof of the Parameters Calibration Method:
CALMO Progress Report

Pavel Khain, Itzhak Carmona (IMS)
Antigoni Voudouri - head of the project, Euripides Avgoustoglou (HNMS)
Jean-Marie Bettems (MeteoSwiss)
Federico Grazzini (ARPA-SIMC)

Special thanks to:
Omar Bellprat (IC3)

January 2015

Report submitted



***+ paper** (in preparation)*

Stage 2

Apply to COSMO-2.2 & 1.1 km

Outline

1. Israel Met. Service (IMS) involvement in COSMO projects
   a. RC^2 (0.8 FTE)
   b. CALMO (0.65 FTE)
   c. Single precision assimilation (POMPA) (0.25 FTE)
   d. XML implementation (VERSUS) (0.15 FTE)
   e. Terra Stand-Alone consolidation (0.15 FTE)

2. COSMO model at IMS
   a. From “Cold” to “Warm” starts, achievements
   b. Problems …
      - Too low humidity at stable stratification
      - Underestimation of light rain in COSMO 2.8km
      - Insufficient penetration of precipitation from sea to land in COSMO 7km

3. Conclusions

1c. Single precision in data assimilation (POMPA)

[Oliver Fuhrer, Alon Shtivelman, Xavier Lapillone, Stefan Rüdisühli and Daniel Leuenberger]

- Goal: save up to 60% run time
- Today: double precision – 8 bits in memory – numbers with:
  - 15 digits of accuracy
  - magnitude between 10^{-308} and 10^{+308}
- Single precision – 8 bits in memory – numbers with:
  - 6-7 digits of accuracy
  - magnitude between 10^{-38} and 10^{+38}
- **In which data assimilation schemes one can move to "single precision" without spoiling the forecast?**

Outline

1. Israel Met. Service (IMS) involvement in COSMO projects
   a. RC^2 (0.8 FTE)
   b. CALMO (0.65 FTE)
   c. Single precision assimilation (POMPA) (0.25 FTE)
   d. XML implementation (VERSUS) (0.15 FTE)
   e. Terra Stand-Alone consolidation (0.15 FTE)
2. COSMO model at IMS
   a. From "Cold" to "Warm" starts, achievements
   b. Problems …
      - Too low humidity at stable stratification
      - Underestimation of light rain in COSMO 2.8km
      - Insufficient penetration of precipitation from sea to land in COSMO 7km
3. Conclusions

1d. VERSUS

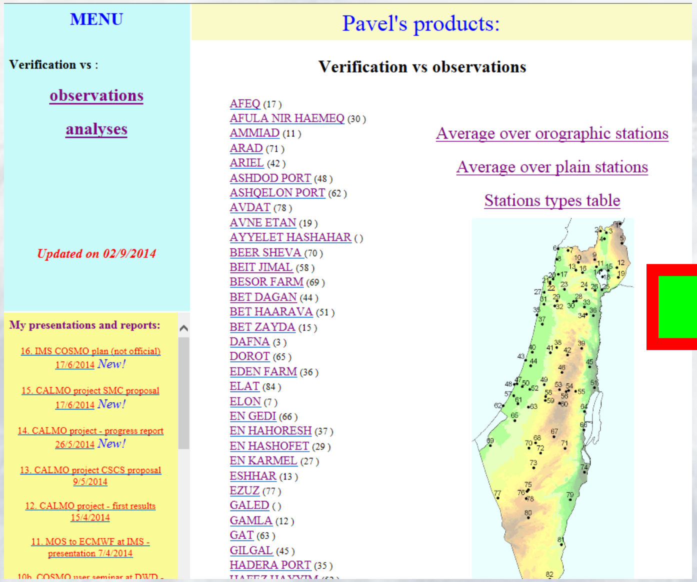
1. XML implementation

[Angela Celozzi, Flora Gofa, Gershon Cohen, Alon Shtivelman, Yoav Levi, Filodea Pastorelli, Antonio Troisi, Pirmin Kaufmann, Petra Baumann]

- Currently – works with data in formats GRIB and TXT.
- Goal: add option for using data in XML format

2. Ongoing verification at IMS *[Alon Shtivelman, Anat Baharad]*

Current verification interface at IMS



In process: moving to VERSUS

Outline

1. Israel Met. Service (IMS) involvement in COSMO projects
   a. RC^2 (0.8 FTE)
   b. CALMO (0.65 FTE)
   c. Single precision assimilation (POMPA) (0.25 FTE)
   d. XML implementation (VERSUS) (0.15 FTE)
   e. Terra Stand-Alone consolidation (0.15 FTE)
2. COSMO model at IMS
   a. From “Cold” to “Warm” starts, achievements
   b. Problems …
      - Too low humidity at stable stratification
      - Underestimation of light rain in COSMO 2.8km
      - Insufficient penetration of precipitation from sea to land in COSMO 7km
3. Conclusions

1e. Terra Stand-Alone consolidation

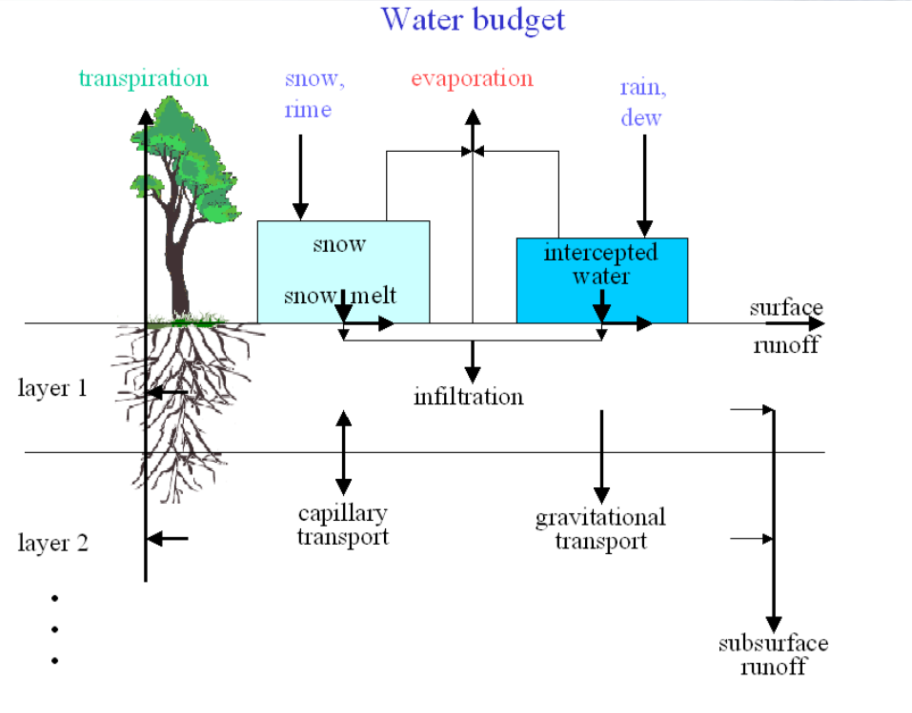
[Itzhak Carmona, Pavel Khain, Yoav Levi, under supervision of Jean-Marie Bettems, Guy de Morsier, thanks to Julian Toedter]

- Soil processes occur slowly → Long "spin-up" until balance with the atmosphere is reached
- If not balanced, running COSMO with soil model – computationally expensive

→ Run Terra Stand-Alone soil model driven by atmospheric analyses

Used for:

- Testing influence of soil parameters variation
- Obtain COSMO soil representation which is balanced with the atmosphere



Hydrologic processes considered in the soil model

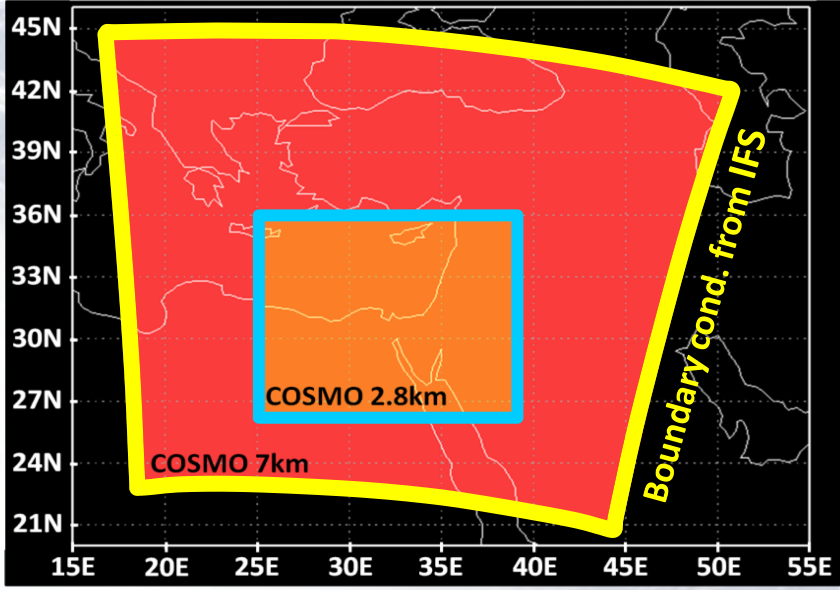
Outline

1. **Israel Met. Service (IMS) involvement in COSMO projects**
   a. **RC²** **(0.8 FTE)**
   b. **CALMO** **(0.65 FTE)**
   c. **Single precision assimilation (POMPA)** **(0.25 FTE)**
   d. **XML implementation (VERSUS)** **(0.15 FTE)**
   e. **Terra Stand-Alone consolidation** **(0.15 FTE)**

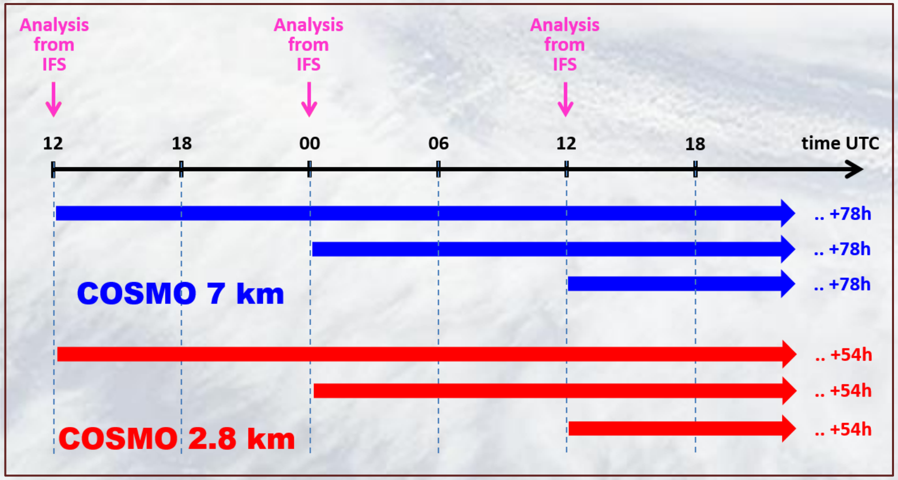
2. **COSMO model at IMS**
   a. **From "Cold" to "Warm" starts, achievements**
   b. **Problems …**
      - Too low humidity at stable stratification
      - Underestimation of light rain in COSMO 2.8km
      - Insufficient penetration of precipitation from sea to land in COSMO 7km

3. **Conclusions**

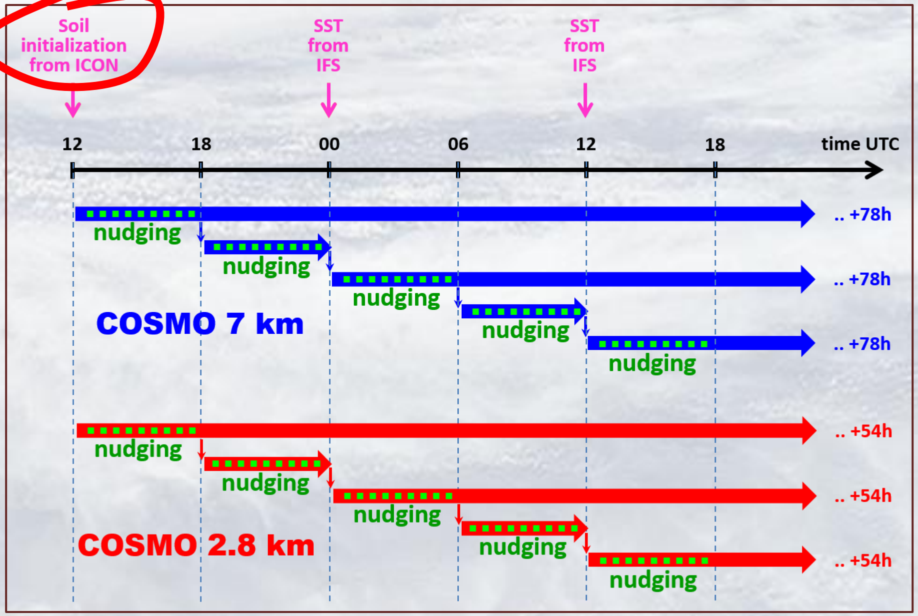
2. COSMO configuration at IMS



OLD: "Cold-starts" version

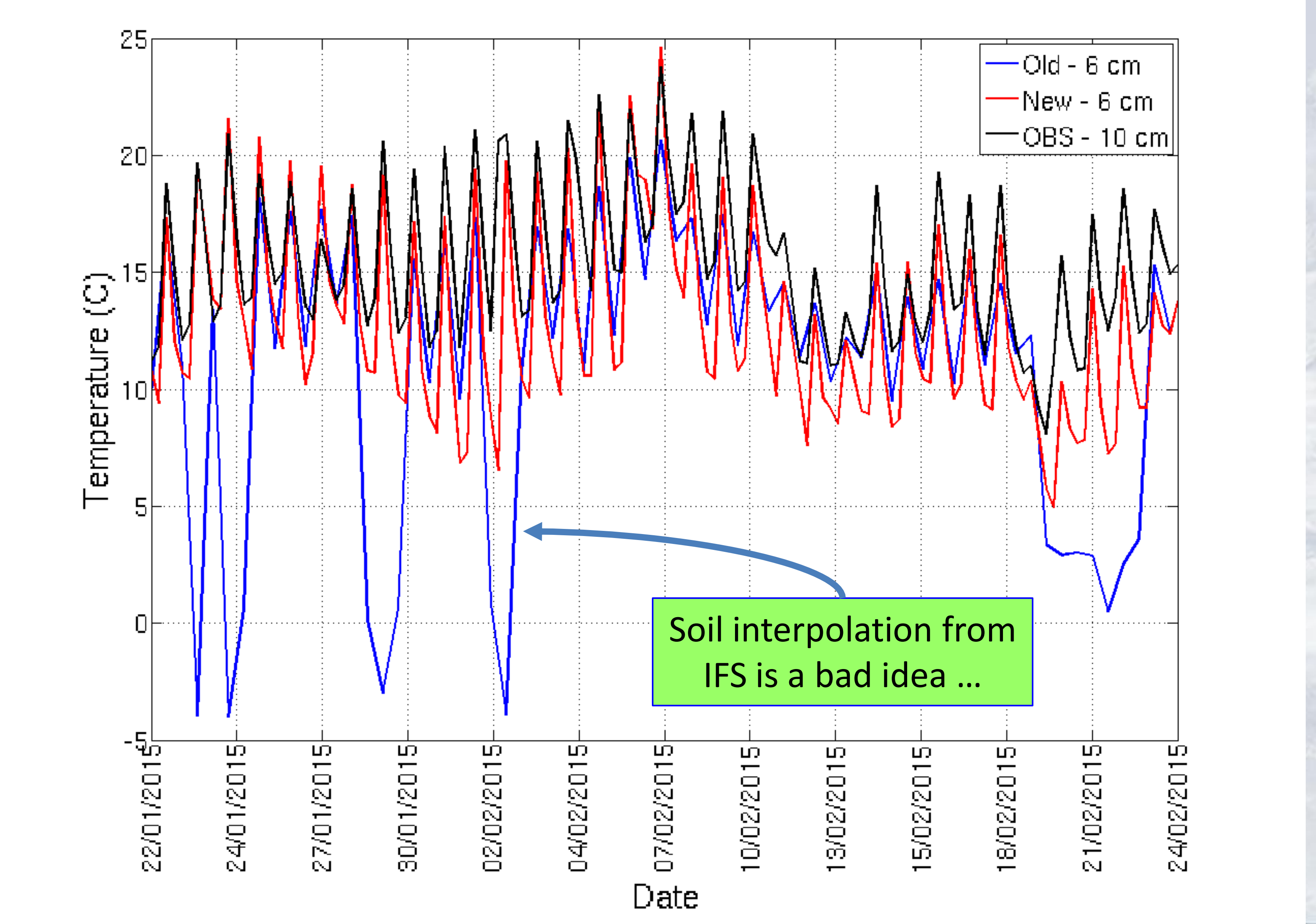


NEW: "Warm-starts" version (ass. cycle)



“Warm starts” (new) vs. “Cold starts” (old)

Soil temperature of the old and new COSMO versions + OBS (at Bet Dagan station)

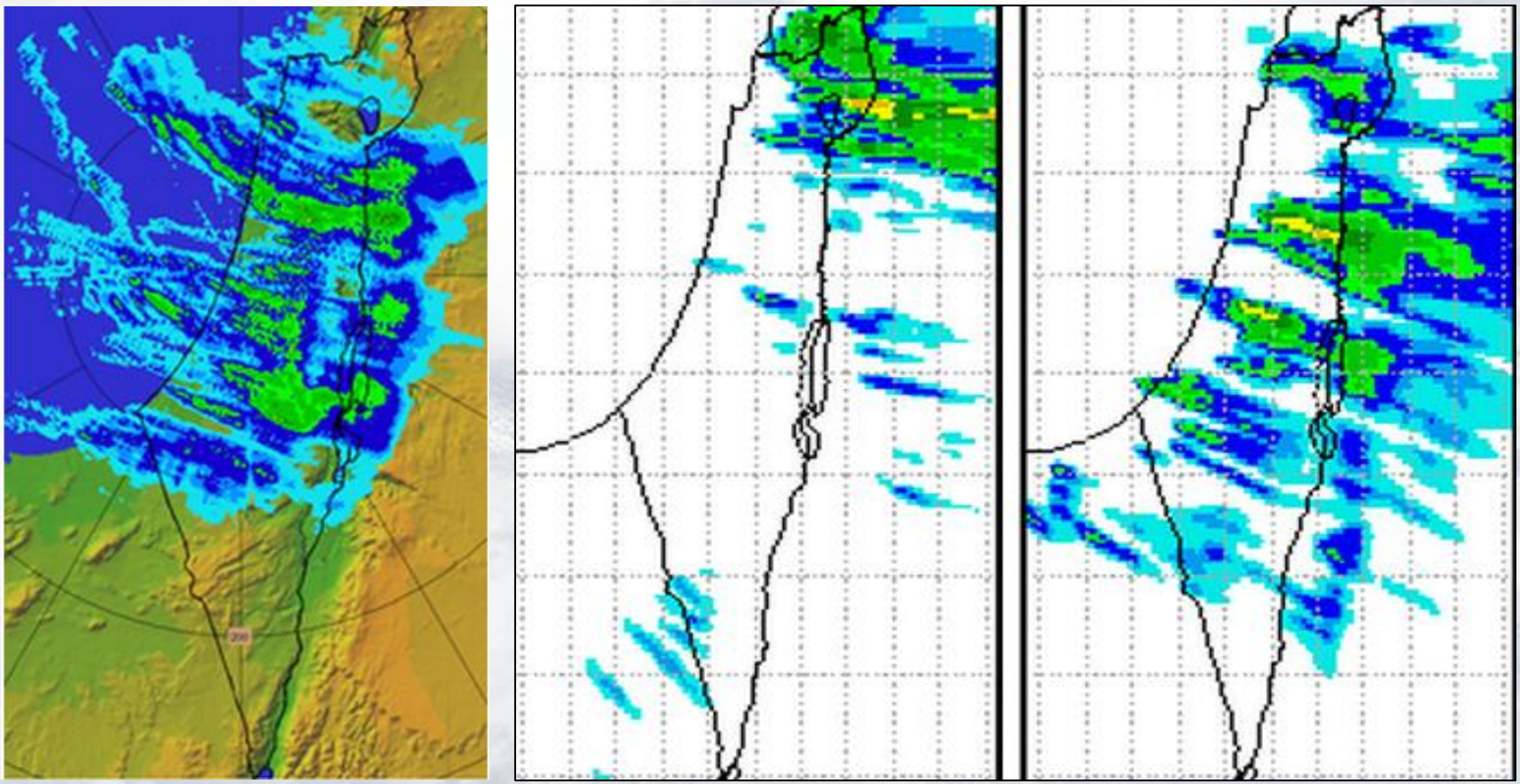


“Warm starts” (new) vs. “Cold starts” (old)

Better precipitation forecast

(although without LH nudging)

RADAR | COSMO 2.8 (OLD) | COSMO 2.8 (NEW)

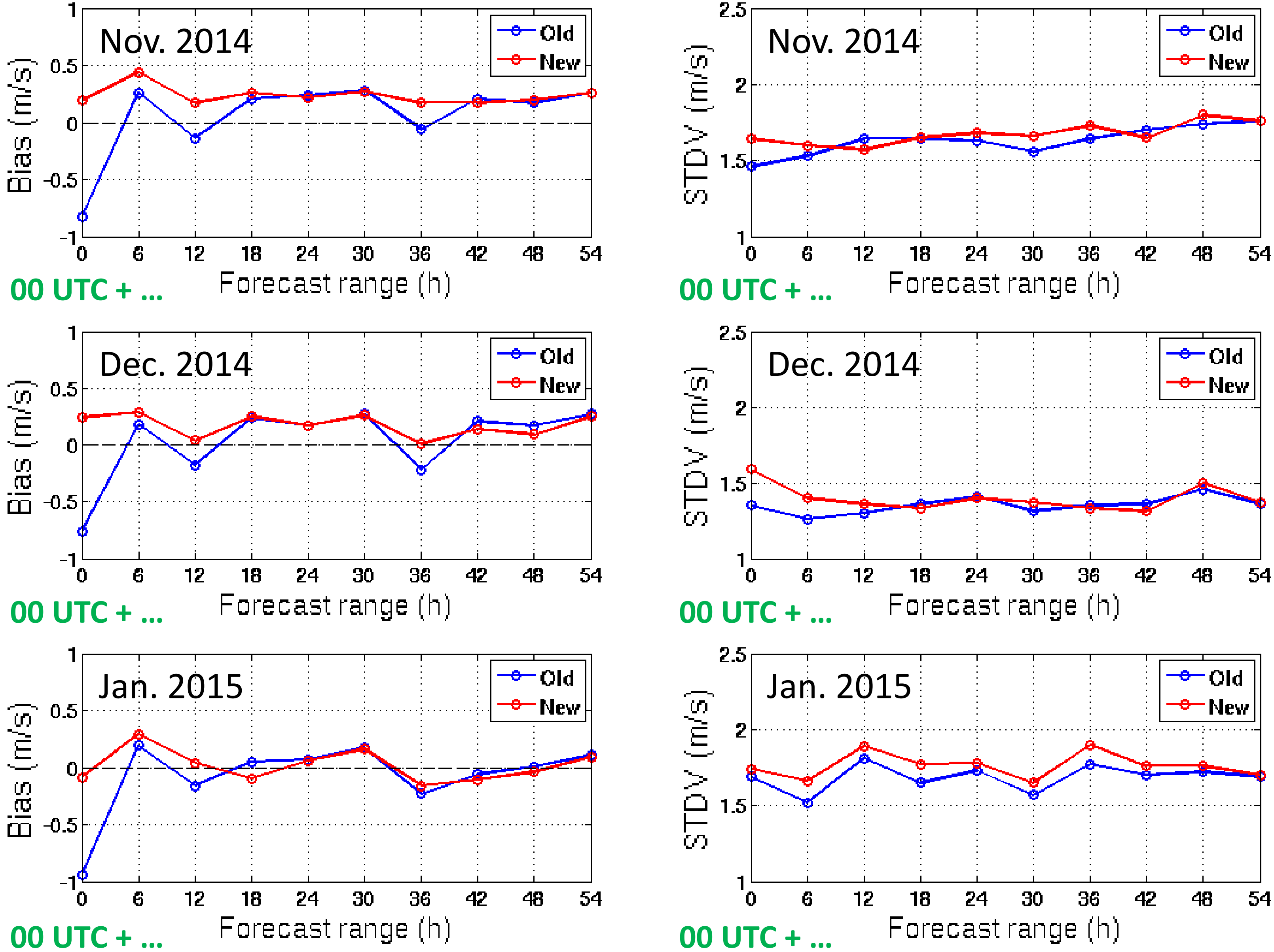


Example: Accum. precipitation forecast 22/12/2015 12 UTC (+6h-12h)

"Warm starts" (new) vs. "Cold starts" (old)

Wind Speed of the two COSMO versions

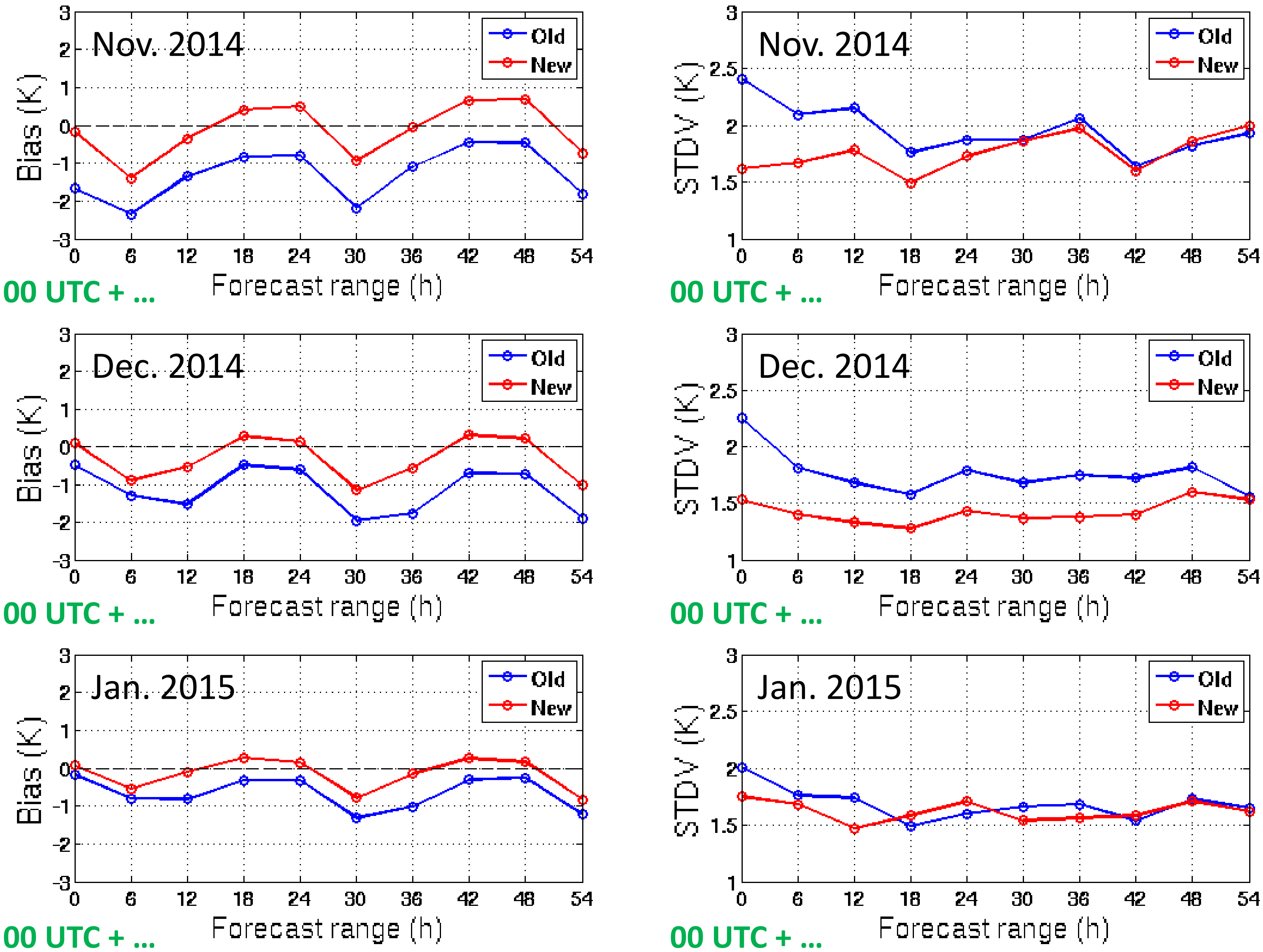
Averaged over 41 complex topography stations



"Warm starts" (new) vs. "Cold starts" (old)

Temperature of the two COSMO versions

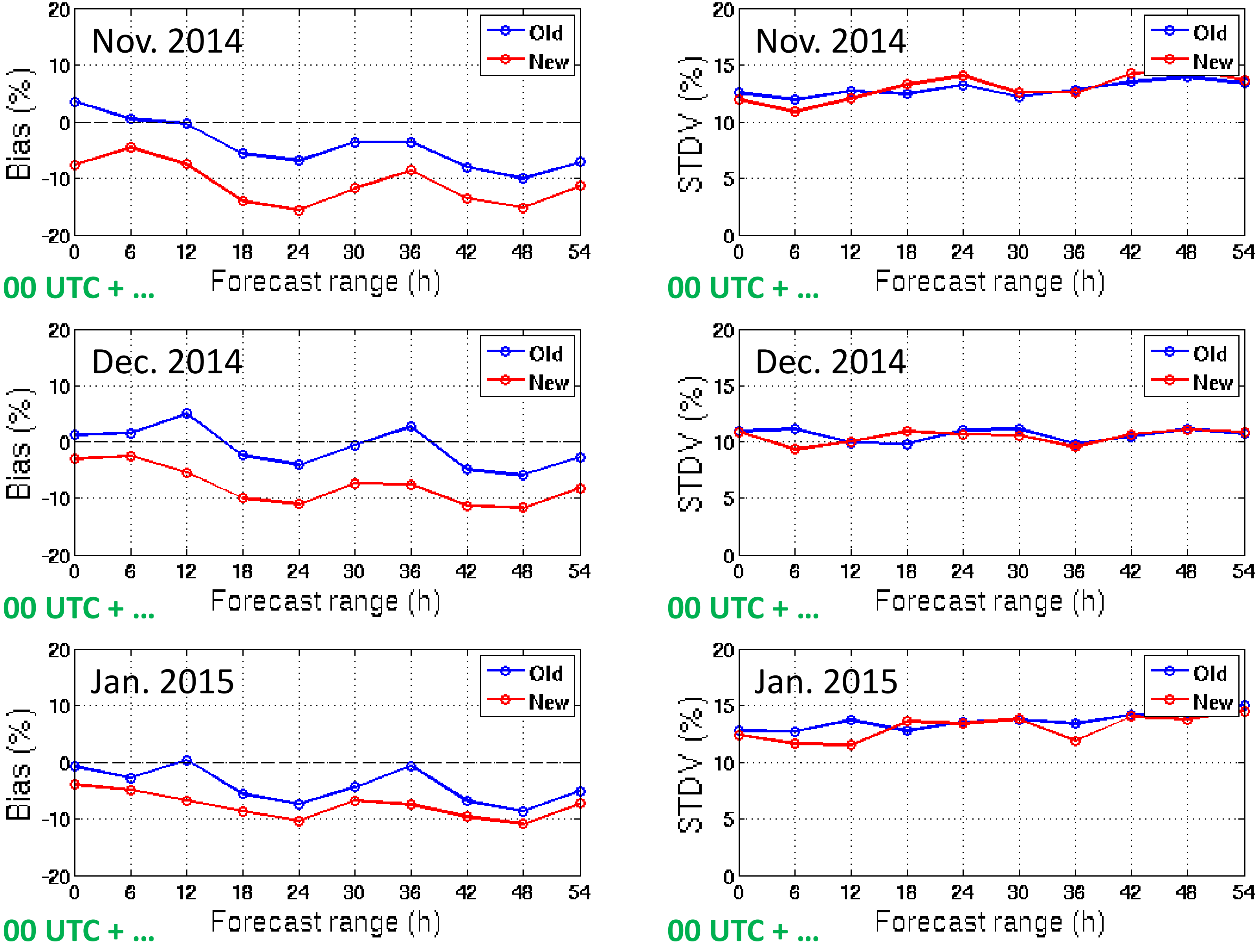
Averaged over 41 complex topography stations



"Warm starts" (new) vs. "Cold starts" (old)

Rel. humidity of the two COSMO versions

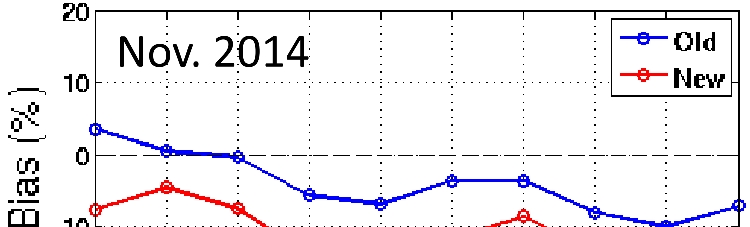
Averaged over 41 complex topography stations

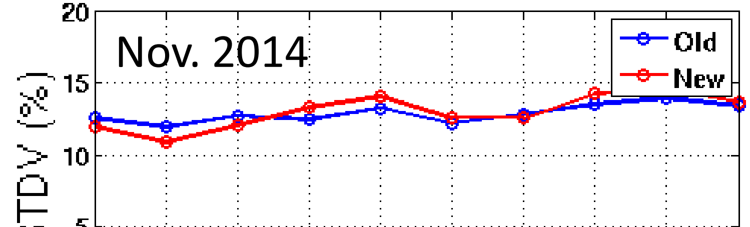


“Warm starts” (new) vs. “Cold starts” (old)

Rel. humidity of the two COSMO versions

Averaged over 41 complex topography stations





Relative humidity is better in the old version !?

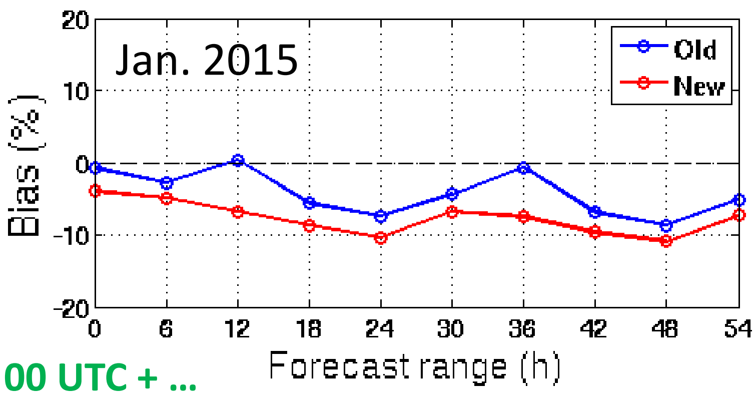
Explanation:

Too low absolute humidity in COSMO!

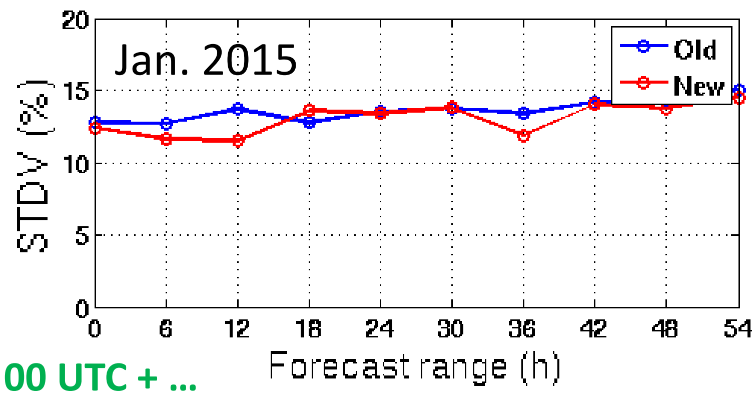
Old version: Too low temperature which compensates abs. humid. error

New version: improved temperature, spoiled rel. humidity

In a few slides…



00 UTC + …



00 UTC + …

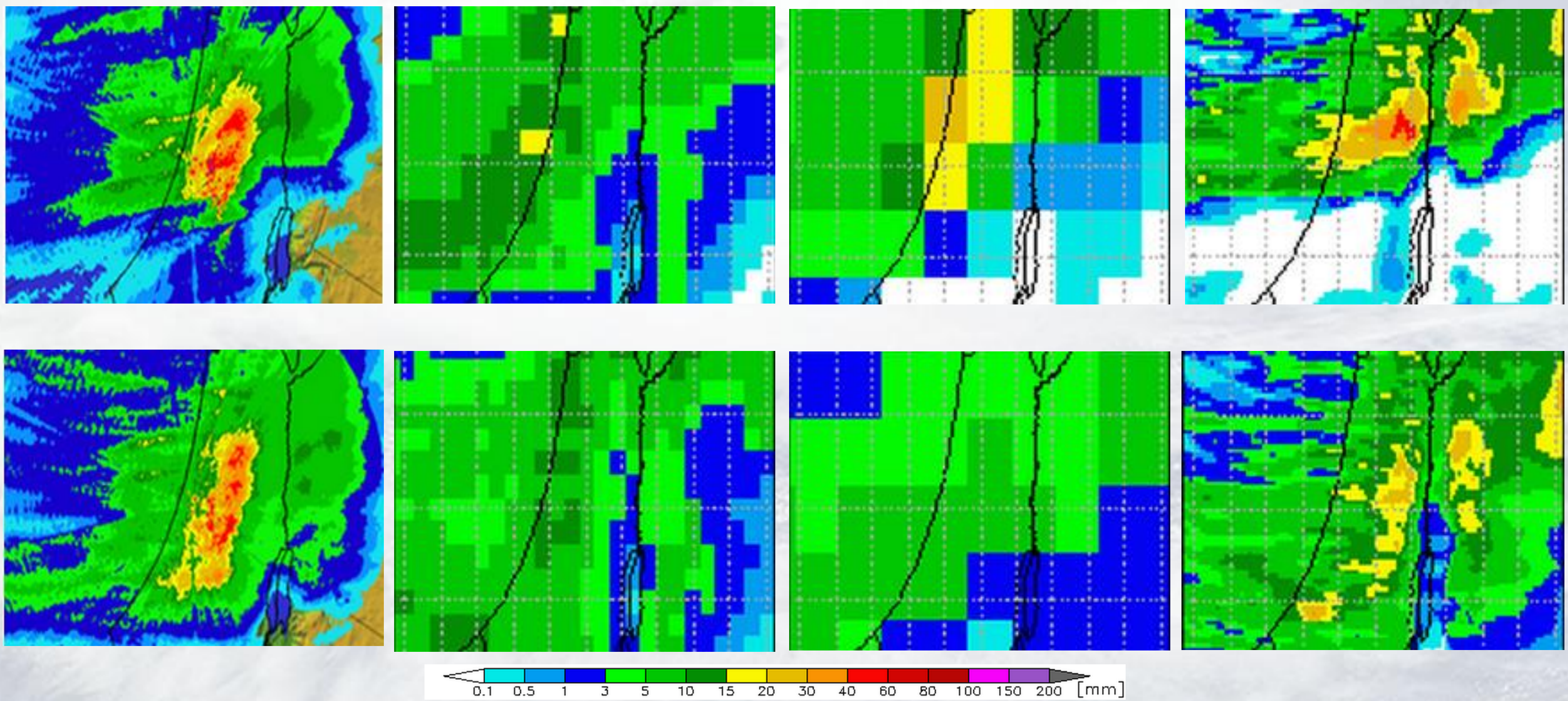
More achievements

Good precipitation amounts in severe storms

Radar | IFS | GME | COSMO 2.8 (NEW)

06-12 UTC

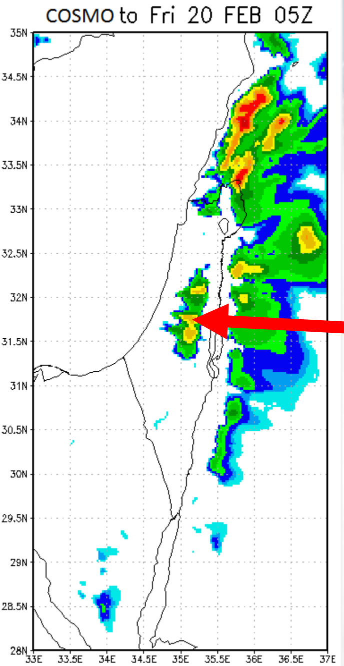
12-18 UTC



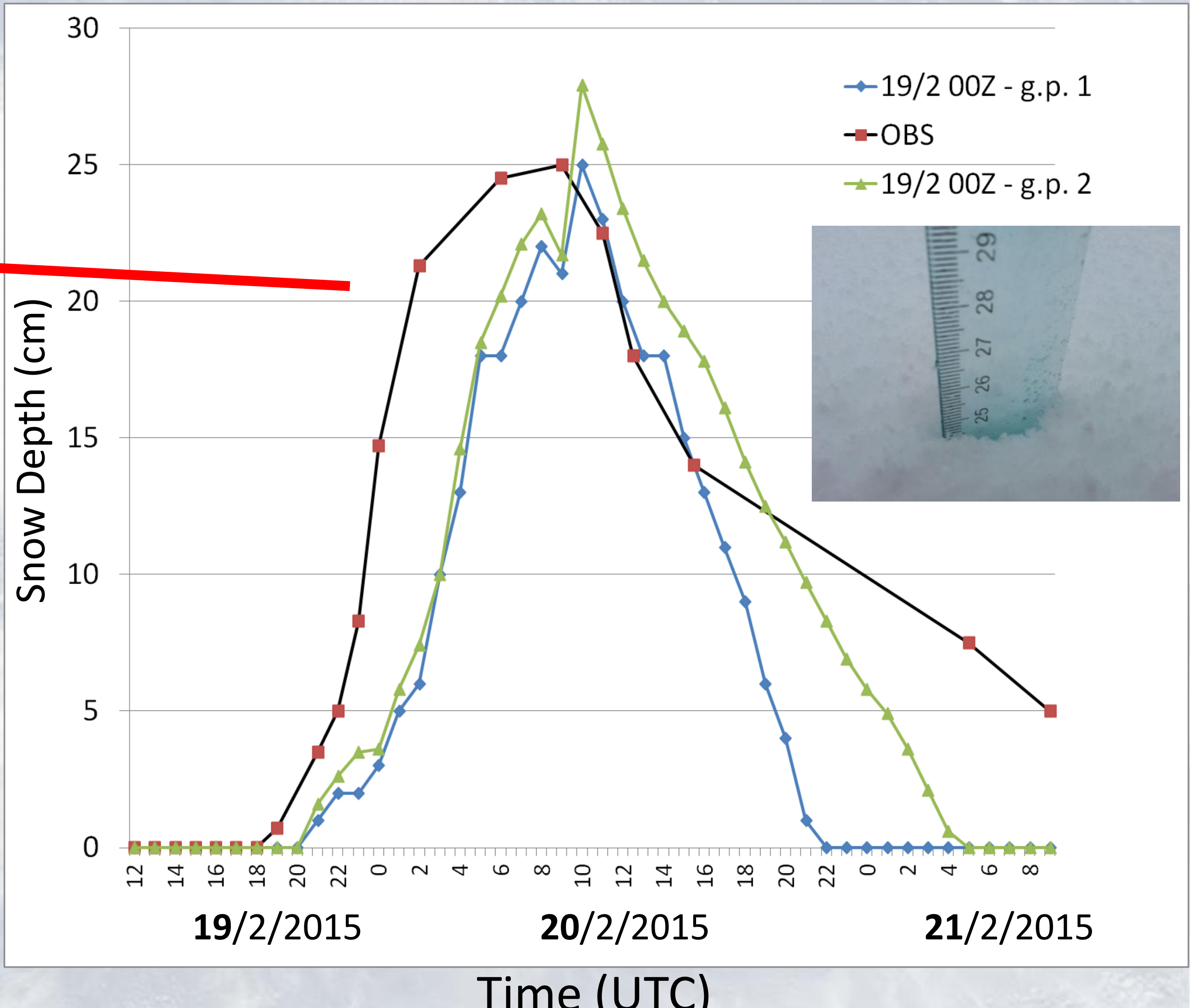
Better amounts!

Example: 6h-accum. precipitation forecast 7/1/2015 00 UTC

More achievements



Snow Depth in Jerusalem, COSMO 2.8 (NEW) vs. Obs.



Outline

1. **Israel Met. Service (IMS) involvement in COSMO projects**
   a. **RC^2** **(0.8 FTE)**
   b. **CALMO** **(0.65 FTE)**
   c. **Single precision assimilation (POMPA)** **(0.25 FTE)**
   d. **XML implementation (VERSUS)** **(0.15 FTE)**
   e. **Terra Stand-Alone consolidation** **(0.15 FTE)**
2. **COSMO model at IMS**
   a. **From "Cold" to "Warm" starts, achievements**
   b. **Problems …**
      - Too low humidity at stable stratification
      - Underestimation of light rain in COSMO 2.8km
      - Insufficient penetration of precipitation from sea to land in COSMO 7km
3. **Conclusions**

An ultra-light plane crashed Sunday morning by the Superland amusement park in Rishon Lezion killing two, MDA reported.

MDA paramedics on site said that the two men were found trapped and dead inside the plane which had been destroyed by fire.

"When we arrived on the scene we saw that the light plane crashed on a roof in the amusement park's compound," said Yehuda Mizrahi, Head of Rishon Lezion's branch of the United Hatzalah rescue forces. "Unfortunately, the two passengers were killed immediately as the plane ignited in flames," he added, saying that firefighters rushed to put out the flames.

"Circumstances of the incident will have to be investigated by police," Mizrahi said.

According tot initial findings, the ultra-light plane took off from a Rishon Lezion landing strip Sunday morning, with a pilot and one passenger on board.

Ten minutes into flight, overtaken by heavy fog, the pilot set to return to the landing strip.

The plane was last spotted entering a cloud of fog and crashing shortly thereafter.

The problem:

Too low humidity at stable stratification

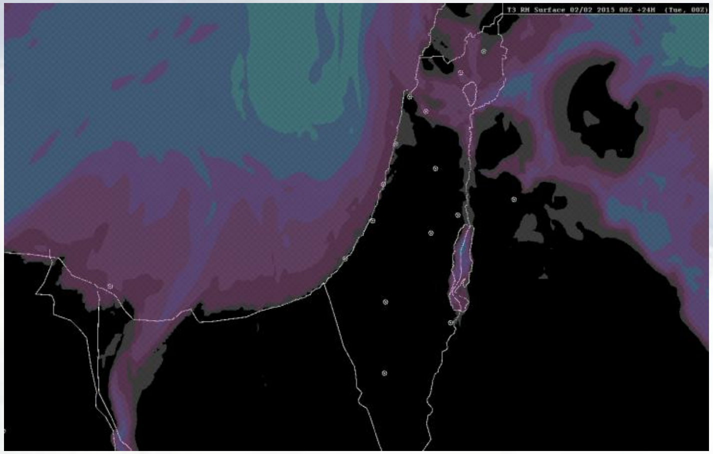
No fogs in the model !

The problem: too low absolute humidity near surface at stable BL

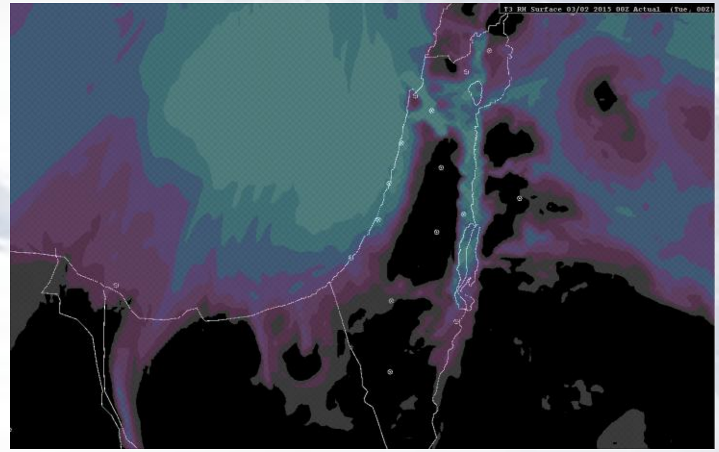
Case study: 3/2/2015 00 UTC

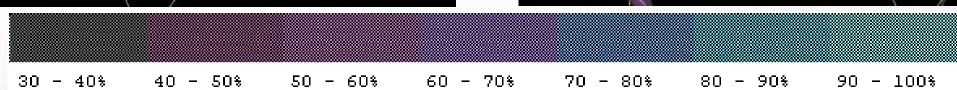
RH (%)

COSMO: 2015/2/2 00Z+24h



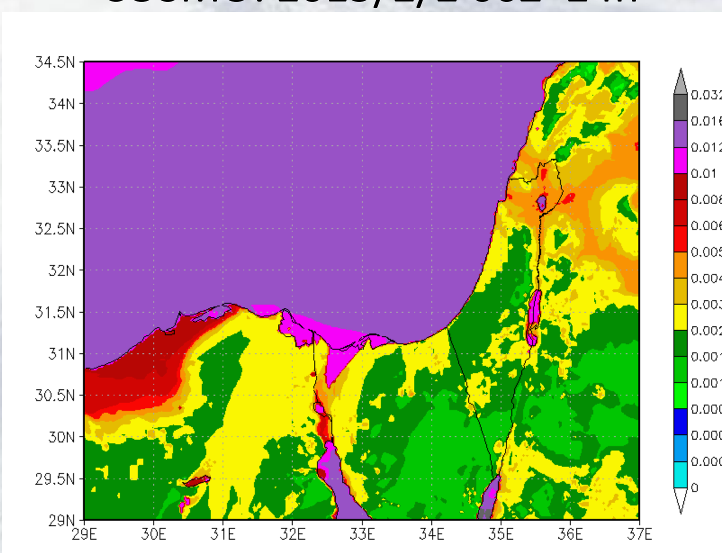
COSMO: 2015/2/3 00Z analysis



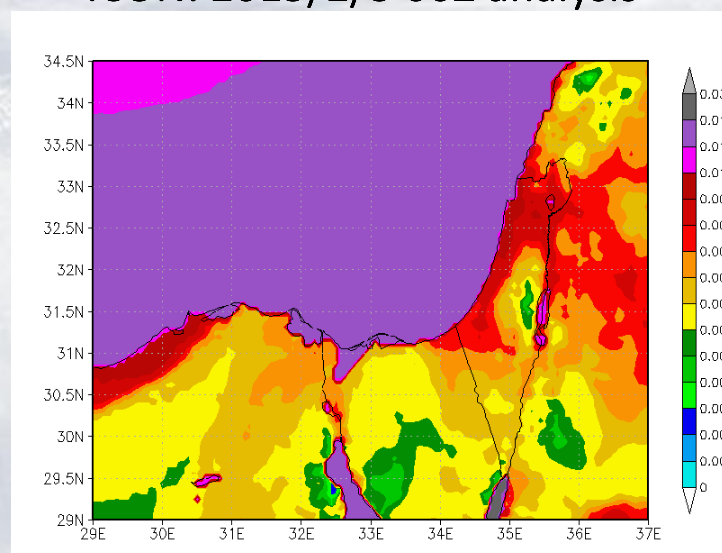


Q_{surf} (kg/m^3)

COSMO: 2015/2/2 00Z+24h

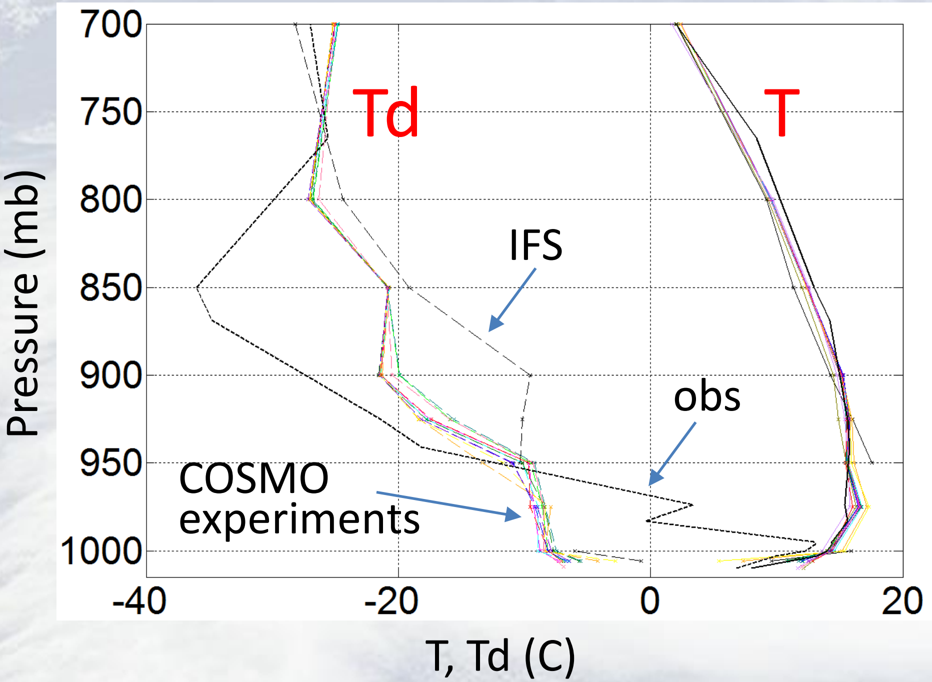


ICON: 2015/2/3 00Z analysis

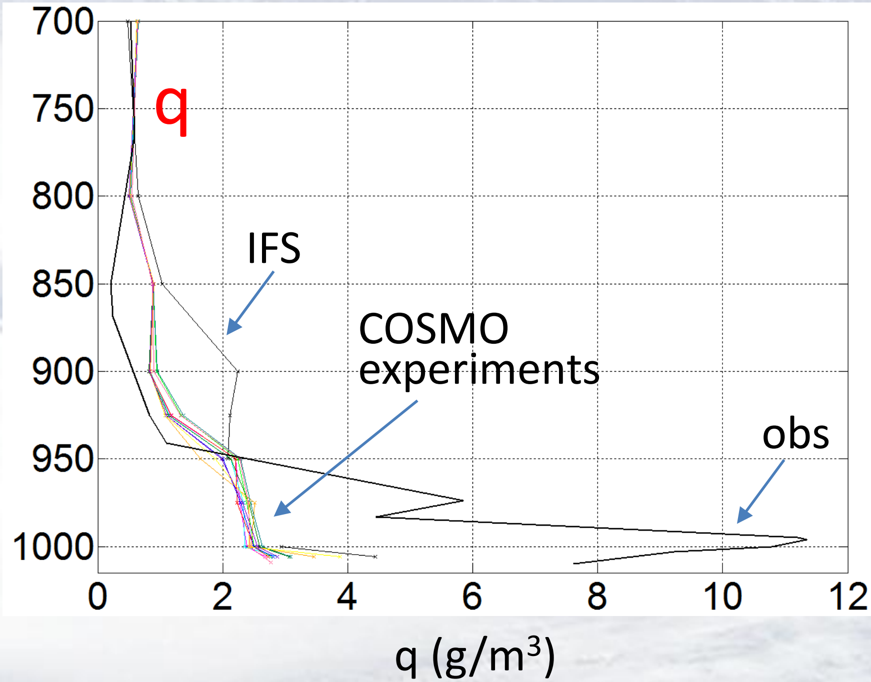


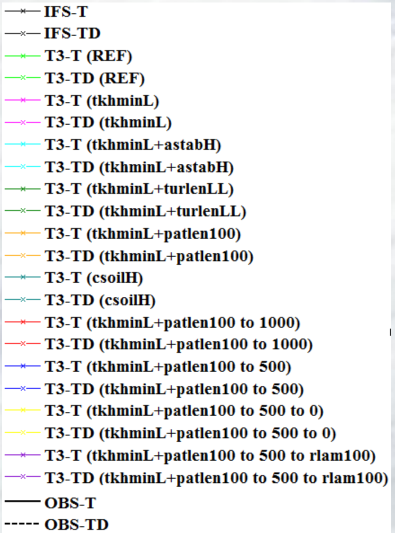
Sensitivity experiments to boundary layer parameters

Temp. and dew point (C)



Absolute humidity (g/m³)





Experiments:

- Reducing assymp. mixing length (tur_len)
- Reducing mixing length in stable regime (a_stab)
- Reducing the minimal turb. coeff. (tkhmin)
- Reducing TKE term due to SGS thermal inhomogeneity of the surface (pat_len)
- Increasing laminar resistance for heat and moisture (rlam_heat)
- Increasing surface-area index of the evaporating fraction of grid points over land (c_soil)

Conclusions:

- **No sensitivity to tested parameters**
- **Too high mixing up to 800 mb**
- **Too low absolute humidity below 950 mb. No fogs!**

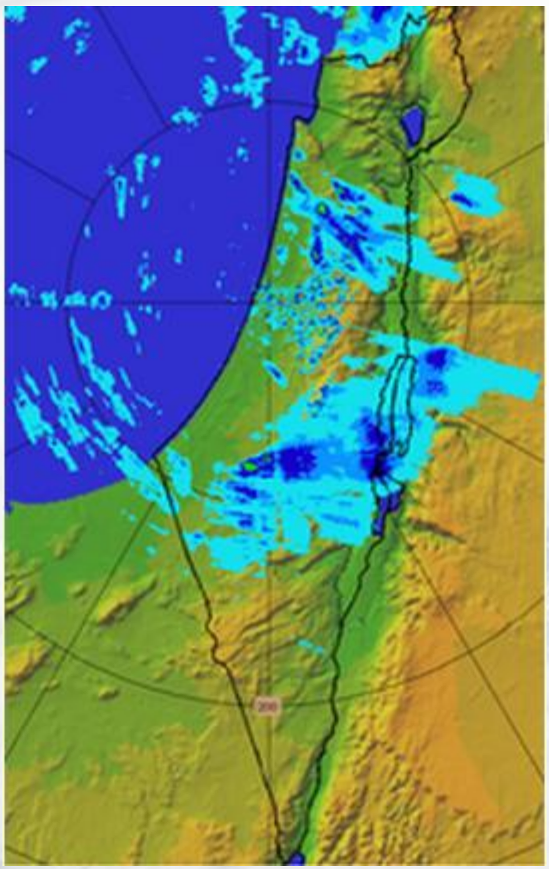
Outline

1. Israel Met. Service (IMS) involvement in COSMO projects
    a. RC^2 (0.8 FTE)
    b. CALMO (0.65 FTE)
    c. Single precision assimilation (POMPA) (0.25 FTE)
    d. XML implementation (VERSUS) (0.15 FTE)
    e. Terra Stand-Alone consolidation (0.15 FTE)
2. COSMO model at IMS
    a. From "Cold" to "Warm" starts, achievements
    b. Problems …
        - Too low humidity at stable stratification
        - Underestimation of light rain in COSMO 2.8km
        - Insufficient penetration of precipitation from sea to land in COSMO 7km
3. Conclusions

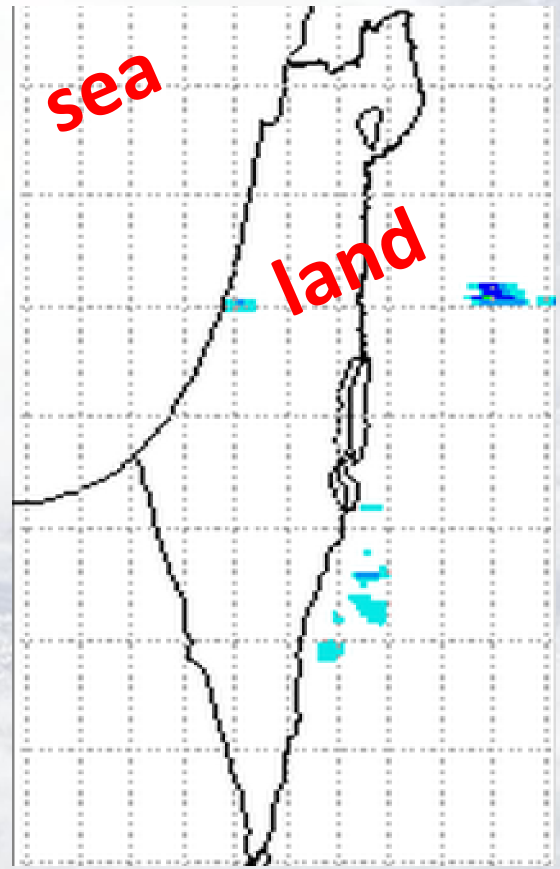
Underestimation of light rain in COSMO 2.8km

Example: Accum. precipitation forecast 14/12/2015 00 UTC (+12h-18h)

RADAR



COSMO 2.8km



Probably "shallow" convection scheme "takes" CAPE from microphysics ?

Outline

1. **Israel Met. Service (IMS) involvement in COSMO projects**
   a. **RC^2** **(0.8 FTE)**
   b. **CALMO** **(0.65 FTE)**
   c. **Single precision assimilation (POMPA)** **(0.25 FTE)**
   d. **XML implementation (VERSUS)** **(0.15 FTE)**
   e. **Terra Stand-Alone consolidation** **(0.15 FTE)**

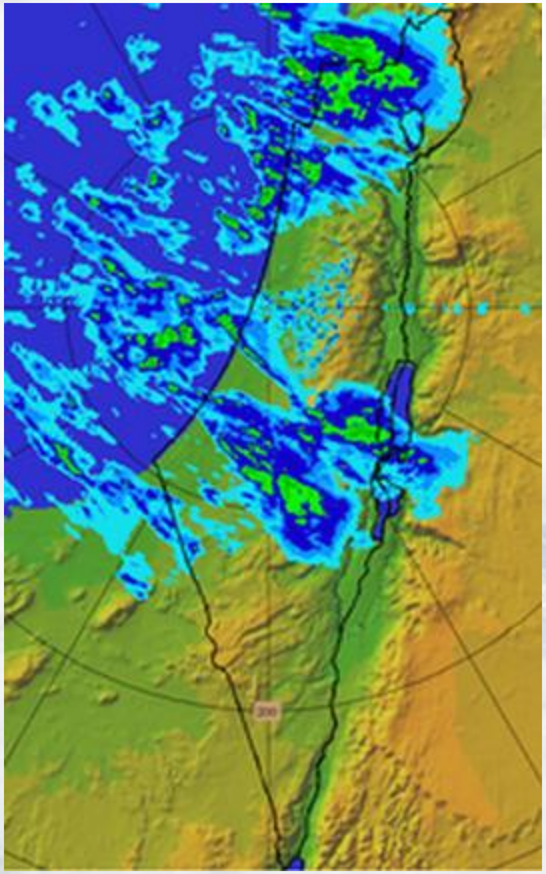
2. **COSMO model at IMS**
   a. **From “Cold” to “Warm” starts, achievements**
   b. **Problems …**
      - Too low humidity at stable stratification
      - Underestimation of light rain in COSMO 2.8km
      - Insufficient penetration of precipitation from sea to land in COSMO 7km

3. **Conclusions**

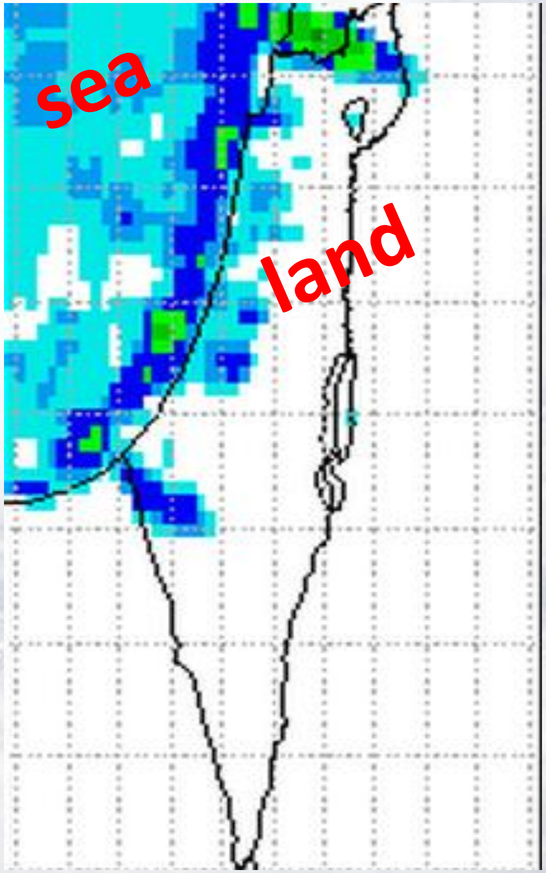
Insufficient penetration of precipitation from sea to land in COSMO 7km

Example: Accum. precipitation forecast 20/12/2015 00 UTC (+24h-30h)

RADAR



COSMO 7km



Probably: Dynamical problem (wrong roughness length over sea/land) ?
Or: Thermal problem (wrong temperature differences between sea/land) ?

Outline

1. **Israel Met. Service (IMS) involvement in COSMO projects**
   a. **RC^2** **(0.8 FTE)**
   b. **CALMO** **(0.65 FTE)**
   c. **Single precision assimilation (POMPA)** **(0.25 FTE)**
   d. **XML implementation (VERSUS)** **(0.15 FTE)**
   e. **Terra Stand-Alone consolidation** **(0.15 FTE)**

2. **COSMO model at IMS**
   a. **From "Cold" to "Warm" starts, achievements**
   b. **Problems …**
      - Too low humidity at stable stratification
      - Underestimation of light rain in COSMO 2.8km
      - Insufficient penetration of precipitation from sea to land in COSMO 7km

3. **Conclusions**

Conclusions

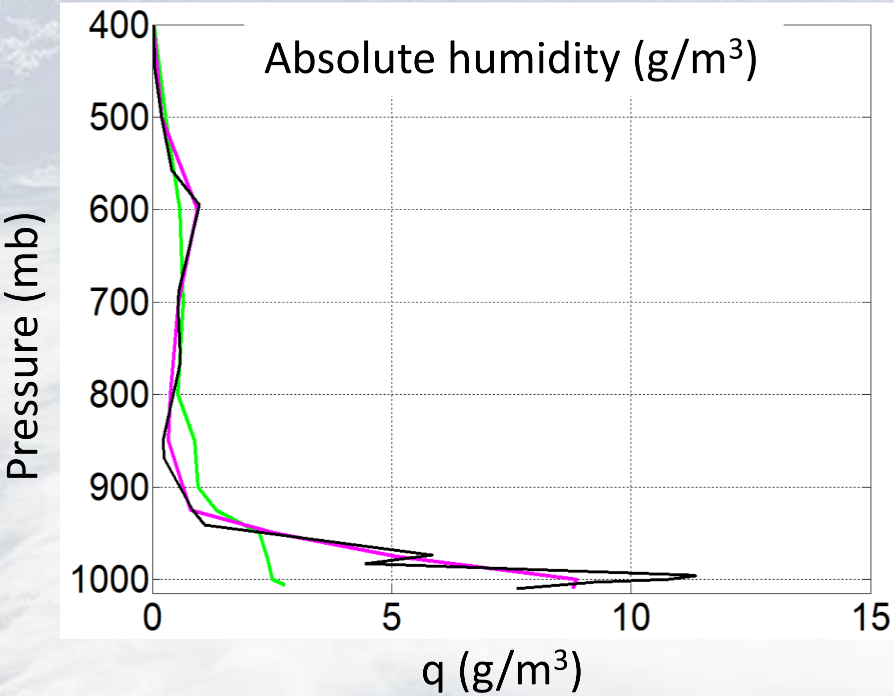
- **IMS is involved in several COSMO projects (RC^2, CALMO, POMPA, VERSUS, TSA)**
- **COSMO with assimilation cycle was implemented at IMS**
- **Achievements: Severe weather, temperature forecasts, soil profiles**
- **Problems:**
  - **Too low absolute humidity in stable boundary layer – no fogs at nights**
  - **Underestimation of light rain in COSMO-2.8km**
  - **Insufficient penetration of precipitation from sea to land in COSMO-7km**

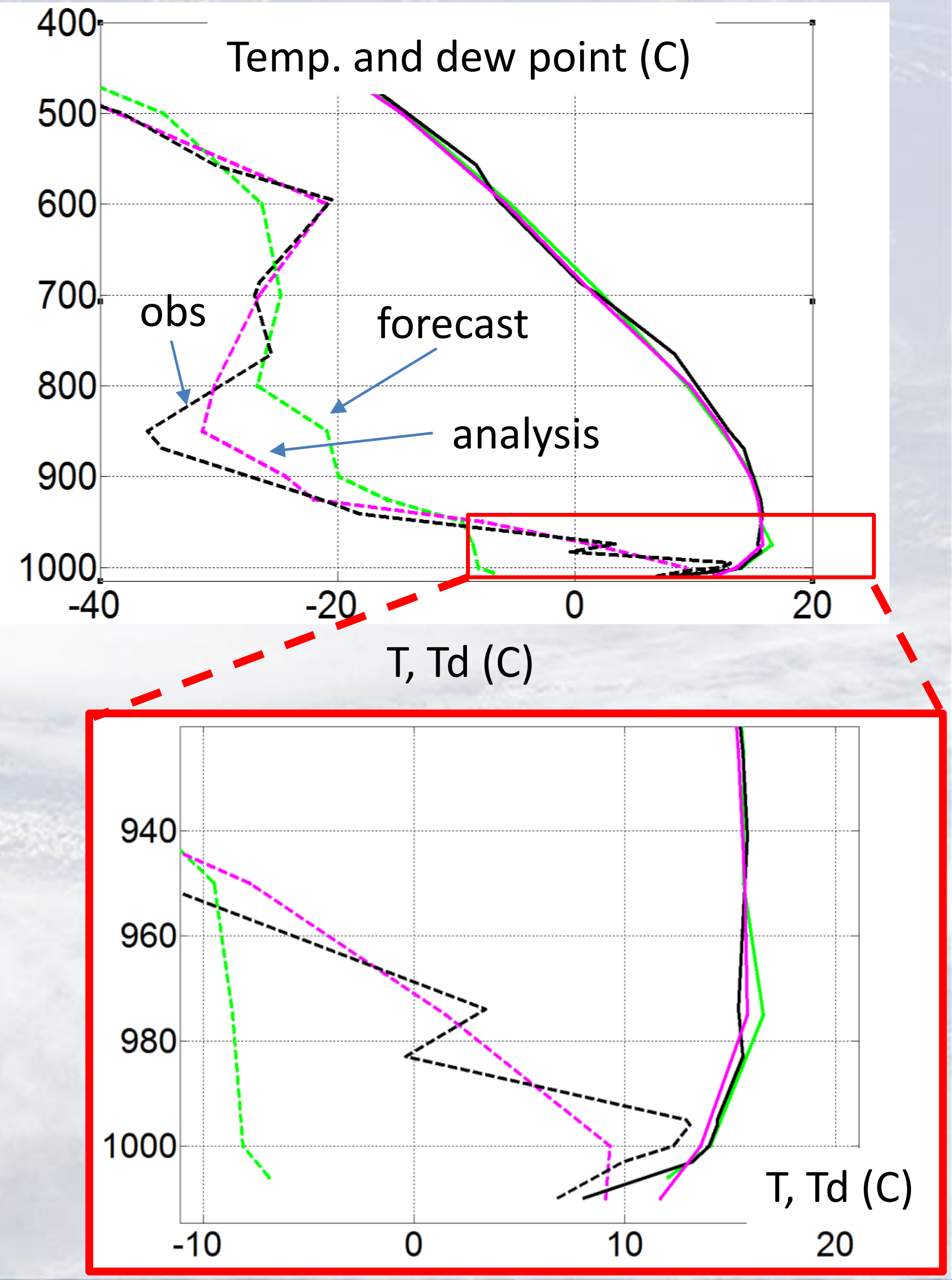
Thank you !

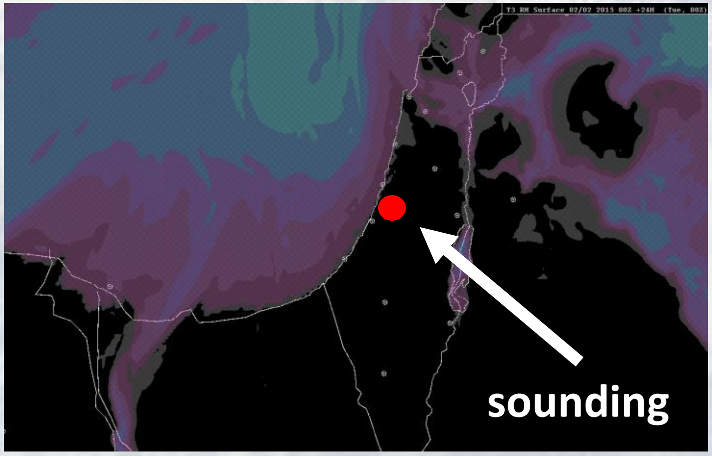
Additional slides …

Description of the stable stratification experiment

The problem: too low <u>absolute</u> humidity near surface at stable BL



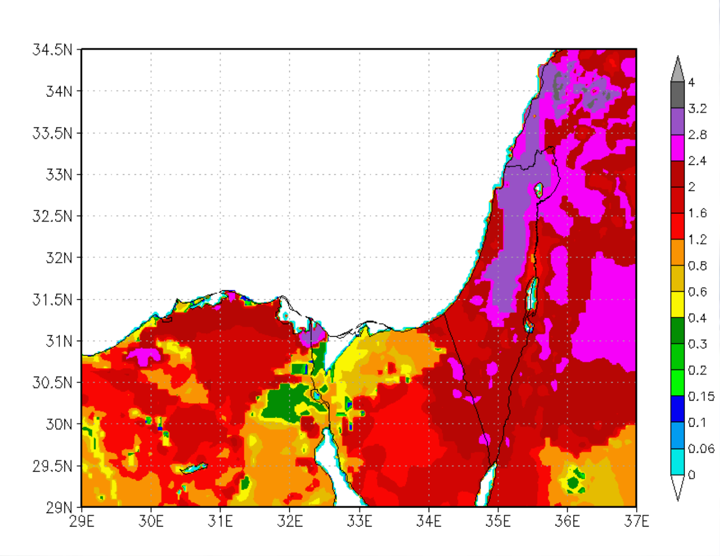




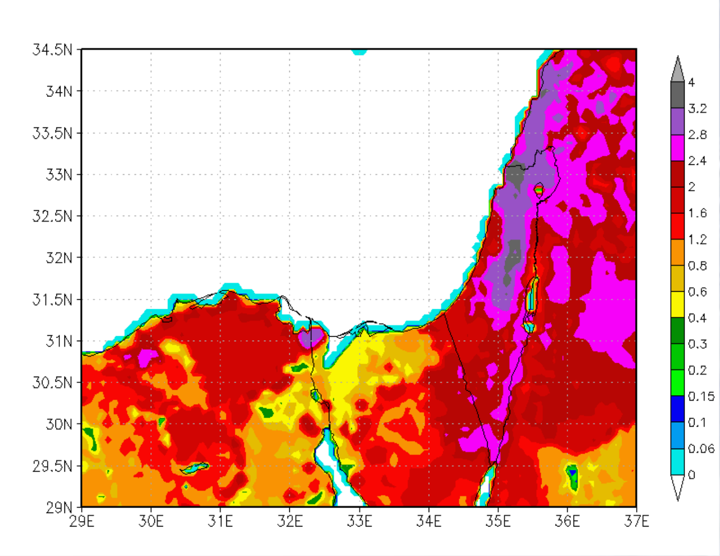
Soil humidity is not the reason

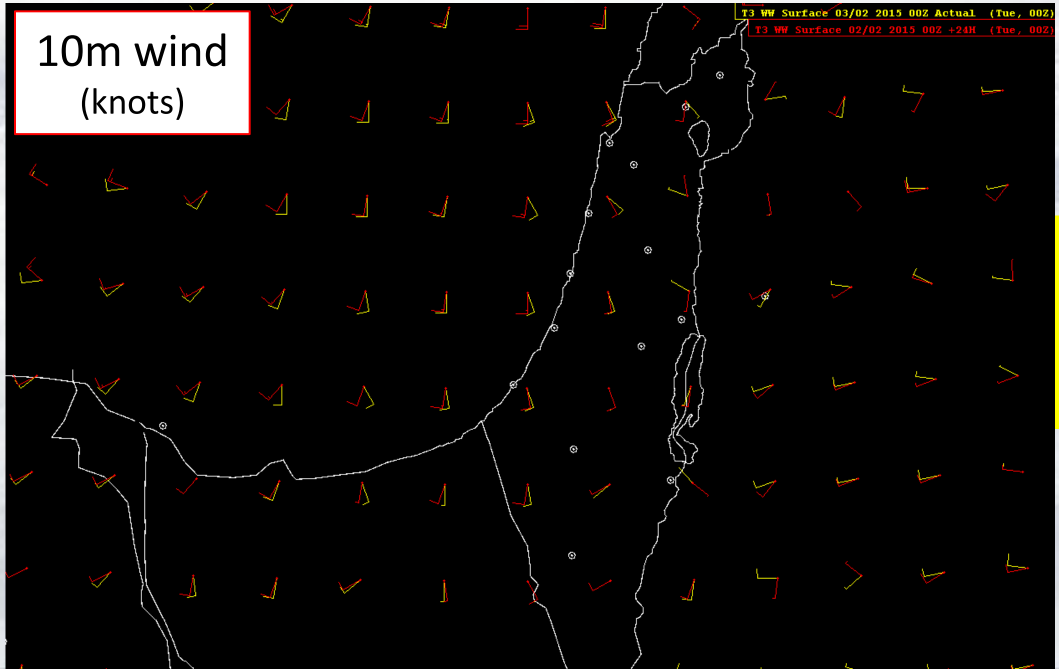
W_SO at 1cm depth (kg/m²)

COSMO: 2015/2/2 00Z+24h



ICON: 2015/2/3 00Z analysis



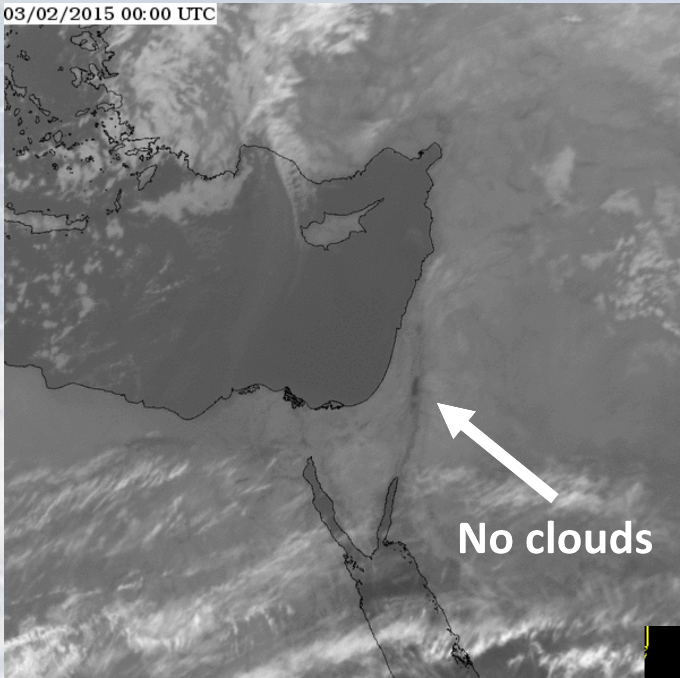


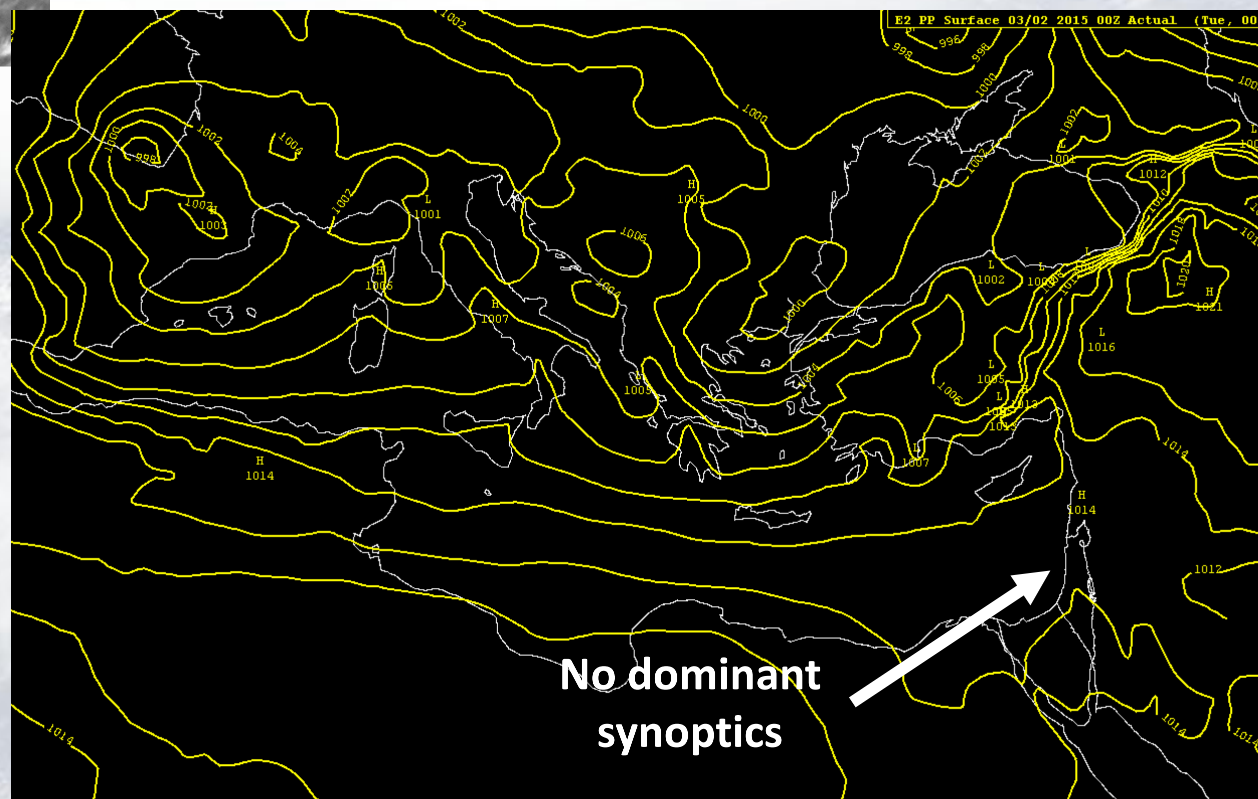
COSMO: 2015/2/2 00Z+24h (yellow)

COSMO: 2015/2/3 00Z analysis (red)

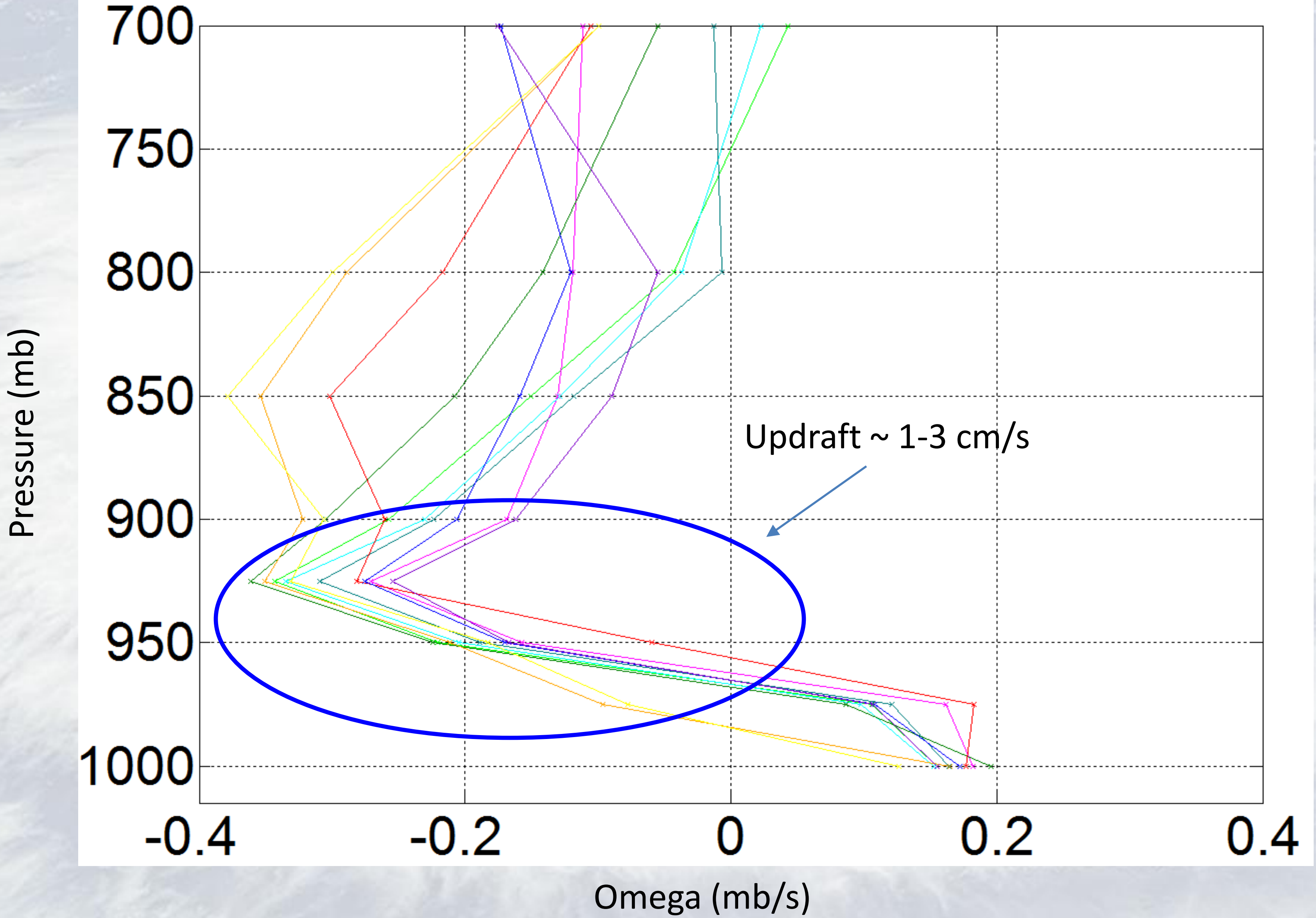
Surface wind is not the reason (seemingly)

Synoptics is not the reason (seemingly)





One probable reason of too high mixing: updrafts which destruct inversion ?



A3 namelist

```
&LMGRID
 startlat_tot  = 26.0, startlon_tot  = 25.0,
 pollat=90.0,       pollon=-180.0,
 dlon=0.025,        dlat=0.025,
 ie_tot=561,        je_tot=401,       ke_tot=60,
/
&RUNCTL
 hstart       = 0.0,
 hstop        = 54.0,
 dt           = 25.0,
 ydate_ini    = '2015030200',
 nprocx       = 23,
 nprocy       = 18,
 nprocio      = 1,
 lphys        = .TRUE.,
 luse_rttov   = .FALSE.,
 luseobs      = .TRUE.,
 leps         = .FALSE.,
 lreorder     = .FALSE.,
 lreproduce   = .FALSE.,
 itype_timing = 4,
 ldatatypes   = .FALSE.,
 ltime_barrier= .FALSE.,
 ncomm_type   = 3,
 nboundlines  = 3,
 idbg_level   = 2,
 lartif_data  = .FALSE.,
 ldfi         = .FALSE.,
 ldiagnos     = .FALSE.,
 hincmxu      = 3.,
 hincmxt      = 3.,
 ldump_ascii  =.FALSE.,
```

```
&TUNING
 rlam_heat=   1.0,
 rlam_mom =   0.0,
 c_soil   =   1.0,
 c_sea    =   1.5,
 c_lnd    =   2.0,
 z0m_dia  =   0.2,
 rat_sea  =   10.0,
 clc_diag =   0.5,
 crsmin   = 150.0,
 qc0      =   0.0002,
 q_crit   =   1.6,
 qi0      =   0.0,
 rat_can  =   1.0,
 rat_lam  =   1.0,
 tur_len  = 150.0,
 pat_len  = 500.0,
 v0snow   =  20.0,
 wichfakt =   0.0,
! mu_rain =   0.0,
 mu_rain  =   2.0,
 rain_n0_factor=0.2,
/
```

```
&IOCTL
!  lasync_io = .FALSE.,
  lasync_io = .TRUE.,
!  ncenter = 234,
  ngribout  = 2,
  ytrans_in = '/Research/models/tmp/IN_3_EC1',
  nincwait  = 10,
  nmaxwait  = 3600,
  ytrans_out = '/Research/models/Output/COSMO-EC/OUT_3_2015030200',
/
&DATABASE
/
&GRIBIN
  hincbound     = 1.0,
  lan_t_so0     =.FALSE.,
  lan_t_cl      =.FALSE.,
  lan_w_cl      =.FALSE.,
  lan_vio3      =.FALSE.,
  lan_hmo3      =.FALSE.,
  lan_plcov     =.FALSE.,
  lan_lai       =.FALSE.,
  lan_rootdp    =.FALSE.,
  lan_t_snow    =.FALSE.,
  lan_w_i       =.FALSE.,
  lan_w_so      =.FALSE.,
  lan_w_snow    =.FALSE.,
  lan_rho_snow  =.FALSE.,
  lchkini       =.TRUE.,
  lchkbd        =.TRUE.,
  lbdana        =.FALSE.,
  lana_qi       =.TRUE.,
  llb_qi        =.TRUE.,
  lana_rho_snow =.TRUE.,
  lana_qr_qs    =.TRUE.,
  llb_qr_qs     =.TRUE.,
  lana_qg       =.FALSE.,
  llb_qg        =.FALSE.,
  ydirini       ='/Research/models/Output/COSMO-EC/OUT_3_2015030118',
  ydirbd        ='/Research/models/tmp/IN_3_EC1',
/
```

```
&INICTL
 ndfi  = 2,
 nfilt = 1,
 tspan = 3600.0,
 dtbak = 25.0,
 dtfwd = 25.0,
 taus  = 3600.0,
/
```

A3 namelist

```
&GRIBOUT
  hcomb=6.0,12.0,6.0,
  luvmasspoint=.TRUE.,
  lanalysis=.TRUE.,
  lcheck=.TRUE.,
  lwrite_const=.TRUE.,
  l_p_filter=.TRUE.,
  l_z_filter=.TRUE.,
  nunit_of_time=1,
  nprocess_ini=23,
  nprocess_bd=23,
  yvarml='U       ','V       ','W       ','T       ',
      'P       ','QV      ','QC      ','QI      ',
      'QR      ','QS      ','QG      ','Q_SEDIM  ',
      'CLC     ','TKE     ','QR      ','QS      ',
      'PS      ','T_SNOW   ','T_S     ','W_SNOW   ',
      'QV_S    ','W_I     ','RAIN_GSP ','SNOW_GSP ',
      'GRAU_GSP ','PRR_GSP  ','PRS_GSP  ','PRG_GSP  ',
      'U_10M    ','V_10M    ','T_2M     ','TD_2M    ',
      'TMIN_2M  ','TMAX_2M  ','VMAX_10M ','TCM      ',
      'TCH     ','CLCT    ','CLCH    ','CLCM    ',
      'CLCL    ','ALB_RAD  ','ASOB_S   ','ATHB_S   ',
      'ASOB_T   ','ATHB_T   ','APAB_S   ','TOT_PREC ',
      'Z0      ','AUMFL_S  ','AVMFL_S  ','ASHFL_S  ',
      'ALHFL_S  ','HTOP_DC  ','RUNOFF_S ','RUNOFF_G ',
      'PMSL    ','T_G     ','HZEROCL  ','CLCT_MOD ',
      'CLDEPTH  ','TDIV_HUM ','TWATER   ','AEVAP_S  ',
      'TQI     ','TQC     ','TQV     ','HBAS_SC  ',
      'HTOP_SC  ','DBZ_850  ','DBZ_CMAX ','T_SO     ',
      'W_SO    ','FRESHSNW ','RHO_SNOW ','FOR_D    ',
      'FOR_E    ','H_SNOW   ','W_SO_ICE ','RELHUM_2M ',
      'ZHD     ','ZTD     ','ZWD     ','CAPE_ML  ',
      'CIN_ML   ','CEILING  ','SDI_1    ','SDI_2    ',
      'HSURF    ','FR_LAND  ','SOILTYP  ','PLCOV    ',
      'LAI     ','ROOTDP   ','VIO3     ','HMO3     ',
      'PP      ','T_SNOW   ','W_I      ','W_SNOW   ',
      'W_SO    ','FOR_E    ','FOR_D    ','SSO_STDH ',
      'SSO_GAMMA ','SSO_THETA ','SSO_SIGMA ',
  ydir='/Research/models/Output/COSMO-EC/OUT_3_2015030200',
/
```

```
&GRIBOUT
  hcomb=0.0,54.0,1.0
  luvmasspoint=.TRUE.,
  lanalysis=.FALSE.,
  lcheck=.TRUE.,
  lwrite_const=.TRUE.,
  l_p_filter=.TRUE.,
  l_z_filter=.TRUE.,
  nunit_of_time=1,
  yvarml='U       ','V       ','W       ','T       ',
      'P       ','QV      ','QC      ','QI      ',
      'QR      ','QS      ','QG      ','Q_SEDIM  ',
      'CLC     ','TKE     ','QR      ','QS      ',
      'PS      ','T_SNOW   ','T_S     ','W_SNOW   ',
      'QV_S    ','W_I     ','RAIN_GSP ','SNOW_GSP ',
      'GRAU_GSP ','PRR_GSP  ','PRS_GSP  ','PRG_GSP  ',
      'U_10M    ','V_10M    ','T_2M     ','TD_2M    ',
      'TMIN_2M  ','TMAX_2M  ','VMAX_10M ','TCM      ',
      'TCH     ','CLCT    ','CLCH    ','CLCM    ',
      'CLCL    ','ALB_RAD  ','ASOB_S   ','ATHB_S   ',
      'ASOB_T   ','ATHB_T   ','APAB_S   ','TOT_PREC ',
      'Z0      ','AUMFL_S  ','AVMFL_S  ','ASHFL_S  ',
      'ALHFL_S  ','HTOP_DC  ','RUNOFF_S ','RUNOFF_G ',
      'PMSL    ','T_G     ','HZEROCL  ','CLCT_MOD ',
      'CLDEPTH  ','TDIV_HUM ','TWATER   ','AEVAP_S  ',
      'TQI     ','TQC     ','TQV     ','HBAS_SC  ',
      'HTOP_SC  ','DBZ_850  ','DBZ_CMAX ','T_SO     ',
      'W_SO    ','FRESHSNW ','RHO_SNOW ','FOR_D    ',
      'FOR_E    ','H_SNOW   ','W_SO_ICE ','RELHUM_2M ',
      'ZHD     ','ZTD     ','ZWD     ','CAPE_ML  ',
      'CIN_ML   ','CEILING  ','SDI_1    ','SDI_2    ',
      'SWDIR_S  ','ASWDIR_S ','SWDIFD_S ','ASWDIFD_S ',
      'SWDIFU_S ','ASWDIFU_S ','LWD_S    ','ALWD_S   ',
      'LWU_S    ','ALWU_S   ','SOD_T    ','ASOD_T   ',
      'QVSFLX   ','DQVDT    ',
  yvarpl='T       ','RELHUM   ','U       ','V       ',
      'FI      ','OMEGA    ','QV      ','DQVDT    ',
  yvarsl='default',

plev=150.0,200.0,250.0,300.0,350.0,400.0,500.0,600.0,650.0,700.0,750.0,800.0,8
25.0,850.0,875.0,900.0,925.0,950.0,975.0,1000.0
  ydir='/Research/models/Output/COSMO-EC/OUT_3_2015030200',
```

A3 namelist

```
&DYNCTL
  l2tls        = .TRUE.,
  lsemi_imp    = .FALSE.,
!  irunge_kutta  = 1,
  irk_order    = 3,
  ldiabf_lh    = .TRUE.,
  iadv_order   = 5,
  itype_bbc_w  = 114,
  betasw       = 0.4,
  epsass       = 0.15,
  lcond        = .TRUE.,
  lspubc       = .TRUE.,
  itype_spubc  = 1,
  itype_hdiff  = 2,
  hd_dhmax     = 250.,
  ldyn_bbc     = .FALSE.,
  lexpl_lbc    = .TRUE.,
  rlwidth      = 50000.0,
  nrdtau       = 5,
  hd_corr_p_bd  = 0.75,
  hd_corr_p_in  = 0.0,
!  hd_corr_q_bd  = 0.0,
!  hd_corr_q_in  = 0.0,
  hd_corr_trcr_bd  = 0.0,
  hd_corr_trcr_in  = 0.0,
  hd_corr_t_bd  = 0.75,
  hd_corr_t_in  = 0.0,
  hd_corr_u_bd  = 0.75,
  hd_corr_u_in  = 0.1,
  itype_outflow_qrsg=2,
 /
```

```
&PHYCTL
  lgsp=.TRUE.,
   itype_gscp=4,
  lrad=.TRUE.,
   nradcoarse=1,
   lradf_avg=.FALSE.,
   hincrad=0.25,
   lforest=.TRUE.,
  ltur=.TRUE.,
   itype_turb=3,
   ninctura=1,
   nincconv=4,
   lexpcor=.FALSE.,
   ltmpcor=.FALSE.,
   lprfcor=.FALSE.,
   lnonloc=.FALSE.,
   lcpfluc=.FALSE.,
   imode_turb=1,
   itype_tran=2,
   imode_tran=1,
   itype_wcld=2,
   icldm_rad =4,
   icldm_turb=2,
   icldm_tran=0,
   itype_synd=2,
   limpltkediff=.TRUE.,
```

```
 lsoil=.TRUE.,
    itype_evsl=2,
    itype_trvg=2,
    lmulti_layer=.TRUE.,
    ke_soil = 7,
    czml_soil = 0.005, 0.02, 0.06, 0.18, 0.54, 1.62,
4.86, 14.58,
   llake=.FALSE.,
   lseaice=.FALSE.,
   lconv=.TRUE.,
    itype_conv=3,
    lcape=.FALSE.,
   lsso=.FALSE.,
    lconf_avg=.TRUE.,
   lmelt=.TRUE.,
   lmelt_var=.TRUE.,
```

A3 namelist

```
 &NUDGING
  itype_obfile=2,
  ycdfdir='/Research/models/tmp/obs',
  lnudge  =.TRUE.,
  lverif  =.FALSE.,
  llhn    =.FALSE.,
  lsurfa  =.FALSE.,
  hnudgsta= 0.0,
!  hnudgend = 6.0,
  hnudgend = 7.0,
  tconbox = 240.0,
  ntpscor = 1,
  ptpstop=400.0,
  luvgcor=.TRUE.,
  khumbal = 100,
  gnudg   = 0.0006, 0.0012, 0.0006, 0.0006,
  gnudgar = .0006, .0000, .0006, .0000,
  gnudgsu = 0.0006, 0.0012, 0.0000, 0.0006,
  ltipol  =.TRUE.,
  tipolmx = 3.0,
  ltipsu  =.TRUE.,
  tipmxsu = 1.0,
  wtukrsa = 3.0,
  wtukrse = 1.0,
  wtukara = 1.5,
  wtukare = 0.5,
  wtuksua = 1.5,
  wtuksue = 0.5,
  msprpar = 1,
  msprpsu = 0,
 vcorls  = .333 , .333 , .04  , .04,
  vcutof  = 0.75, 0.75, 1.0 , 1.0,
  vcorlsu = .013 , .013 , .002 ,.00001,
  vcutosu = 0.75, 0.75, 4.0 ,0.001,
  rhinfl =    0.,   70.,    0.,    0.,
  rhvfac  = 1.0 , 0.0 , 0.83, 0.83,
  rhtfac  = 1.3 , 1.43, 1.3 , 1.3,
  cutofr  = 3.5 , 3.5 , 3.5 , 3.5,
  rhiflsu =   70.,   70.,  100.,   70.,
  rhtfsu  = 1.0 , 1.43, 1.0 , 1.0,
  cutofsu = 2.0 , 3.5 , 2.0 , 2.0,
  vcsnisu = 2500., 2500., 9.   , 9.,
  fnondiv = 0.8,
  cnondiv = 0.1,
  tnondiv = 1.1,
  lscadj  =.TRUE.,.TRUE.,.TRUE.,.FALSE.,
  topobs  =  849., 1099.,  799.,  699.,
  botmod  = 1099., 1099., 1099.,  899.,
  dtqc    =  720.,
  qcvf    = 5.0 , 1.0 ,10.0 , 0.0,
  qcc     =    0.,  500.,    0.,    .7,
  qccsu   =   12.,  500.,   12.,    .7,
  nolbc = 5,
  altopsu =  100., 5000., 5000., 5000.,
  thairh  = 20.,
  exnlat  = 90.,
  exslat =-90.,
  exwlon = -180.,
  exelon = 180.,
  lsynop  =.TRUE.,
  laircf  =.TRUE.,
  ldribu  =.TRUE.,
  ltemp   =.TRUE.,
  lpilot  =.TRUE.,
  lcd132  =.TRUE.,
  lcd133=.FALSE.,
  lcd136=.FALSE.,
  maxmlo  = 700,
 maxsgo = 4000,
  maxuso = 2500,
  lprodr =.TRUE.,
  noctrq = 9,
  dinlat  = 55.,
  dislat = 45.,
  diwlon =  7,
  dielon = 14.,
  lhn_black=.FALSE.,
/
```

Name	Type	Definition / Purpose / Comments	Default	Depend.
`tkesmot`	`REAL`	Time smoothing factor for TKE to reduce the time variability of the diffusion coefficient. Formel ???. Should be chosen as small as possible. (`tkesmot` $\in [0,2]$)	`0.15`	???
`wichfakt`	`REAL`	Vertical smoothing factor for explicit vertical diffusion coefficients. (`wichfakt` $\in (0,0.5]$)	`0.0`	dt
`securi`	`REAL`	Security factor for maximal diffusion coefficients for explicit vertical diffusion. (`securi` $\in (0,1]$)	`0.85`	dz
`tkhmin`	`REAL`	Minimal diffusion coefficients for heat active in stable BL conditions. (`tkhmin` $\in [0,2]$)	`0.4`	dz,R
`tkmmin`	`REAL`	Minimal diffusion coefficients for momentum active in stable BL conditions. (`tkmmin` $\in [0,2]$)	`0.4`	dz,R
`z0m_dia`	`REAL`	Typical roughness length for a Synop station, which is used for the interpolation of screen-level values of the 10-m wind (instead of using the actual roughness length at the grid-point) and T_{2M}. (`z0m_dia` $\in [0.001,10]$). Modifies the T_2M calculation.	`0.2`	
`rat_lam`	`REAL`	Ratio of laminar boundary layer thickness for water wapour and sensible heat. Higher values allow to ... the Bowen ratio. (`rat_lam` $\in [0.1,10]$)	`1.0`	
`rat_can`	`REAL`	Scaling factor for the calculation of the canopy height affecting the diagnostics of T_{2M} (`rat_can` $\in [0,10]$). Removed in 5.0.	`1.0`	
`rat_sea`	`REAL`	Scaling factor for `rlam_heat` (for scalars) over sea. (`rat_sea` $\in [1,100]$).	`20.0`	
`pat_len`	`REAL`	Length scale (m) of sub-scale surface patterns over land. (`pat_len` $\in [0,10000]$). Removed in 5.0.	`500.0`	dx
`tur_len`	`REAL`	Maximal turbulent length scale (m). (`tur_len` $\in [0,10000]$)	`500.0`	

c_lnd	REAL	Surface-area index of gridpoints over land (excluding leaf-area index) used in ???. (c_lnd ∈ [1, 10]). Formula: ???.	2.0	
c_sea	REAL	Surface-area index of gridpoints over sea used in ???. (c_sea ∈ [1, 10]). Formula: ???.	1.5	
c_soil	REAL	Surface-area index of the evaporating fraction of gridpoints over land used in ???. (c_soil ∈ [0, c_lnd]). Formula ???.	1.0	
e_surf	REAL	Exponent to get the effective surface area used in ??? (Why needed additionally to c_{xxx}). (e_surf ∈ [0.1, 10]).	1.5	
rlam_heat	REAL	Scaling factor for the thickness of the laminar boundary layer for heat. Formula: ???. (rlam_heat ∈ [0.1, 10])	1.0	
rlam_mom	REAL	Scaling factor for the thickness of the laminar boundary layer for momentum. Formula: ???. (rlam_mom ∈ [0, 1])	0.0	
a_heat	REAL	Factor for turbulent heat transport. (a_heat ∈ [0.01, 100]) Removed in 5.0.	0.74	
a_mom	REAL	Factor for turbulent momentum transport. (a_mom ∈ [0.01, 100]) Removed in 5.0.	0.92	
a_hshr	REAL	Length scale factor for separate horizontal shear production of TKE. Introduced in Version 4.10.	0.2	
a_stab	REAL	Length scale factor for the stability correction. Introduced in Version 4.10.	0.0	
d_heat	REAL	Factor for turbulent heat dissipation. (d_heat ∈ [0.01, 100]). Removed in 5.0.	10.1	
d_mom	REAL	Factor for turbulent momentum dissipation. (d_mom ∈ [0.01, 100]). Removed in 5.0.	16.6	
c_diff	REAL	Factor for turbulent diffusion of TKE. (c_diff ∈ [0, 10]).	0.2	

Name	Type	Definition / Purpose / Comments	Default	Depend.
clc_diag	REAL	Cloud cover at saturation in statistical cloud diagnostic. ($\texttt{clc\_diag} \in (0, 1)$)	0.5	
q_crit	REAL	Critical value for normalized over-saturation. ($\texttt{q\_crit} \in [1, 10]$)	4.0	
crsmin	REAL	Minimum value of stomatal resistance (used by the BATS approach for vegetation transpiration, itype_trvg=2). ($\texttt{crsmin} \in [50, 200]$)	150.0	
qc0	REAL	Cloud water threshold for autoconversion.	0.0	
qi0	REAL	Cloud ice threshold for autoconversion.	0.0	
entr_sc	REAL	Mean entrainment rate for shallow convection. Introduced in Version 4.5.	0.0003	
thick_sc	REAL	limit for convective clouds to be "shallow" (in Pa). Recommended values for thick_sc: $\texttt{thick\_sc} \in [10000.0, 45000.0]$ Introduced in Version 4.18.	25000.0	
mu_rain	REAL	Shape parameter of the rain drop size distribution. Reasonable values are: $\texttt{mu\_rain} \in [0.0, 5.0]$. Introduced in Version 4.5. ATTENTION: In Version 4.21 the default value has been changed from 0.5 to 0.0!	0.0	
rain_n0_factor	REAL	To reduce the evaporation of rain drops. Reasonable values are: $\texttt{rain\_n0\_factor} \in [0.0, 1.0]$. Introduced in Version 4.14.	1.0	
cloud_num	REAL	Cloud droplet number concentration.	5.0 E+08	
v0snow	REAL	Factor in the terminal velocity for snow. This was a local variable in the subroutines hydci_pp and hydci_pp_gr before, but had different values. To reproduce the results from the former version, the following values have to be set: itype_gscp = 3 and Leapfrog dynamics: 15.0 itype_gscp = 3 and Runge-Kutta dynamics: 25.0 itype_gscp = 4 and Runge-Kutta dynamics: 20.0 Introduced in Version 4.14.	25.0	

Abstract

The 5.0 version of the COSMO model with 7 km and nested 2.8 km resolution and 60 vertical levels has been adopted in 6h-assimilation cycle at the Israel Meteorological Service (IMS). The model runs are performed using IFS driving data over the eastern Mediterranean. In contrast, the currently operational version at IMS is based on “cold starts”, i.e. initialized by the interpolated IFS analyses, without data assimilation. We compare the COSMO forecasts using “assimilation cycle” with those using “cold starts”. The results show an enormous improvement of the 2m-temperature forecasts in the “assimilation cycle” version. This improvement can be attributed to excluding errors during the model spinup, as well as excluding errors caused by the interpolation of IFS analyses to the COSMO grid, which are especially large at the soil and near surface layers. Significant changes were found in other forecast fields as well. The algorithm of the assimilation cycle, as well as the reasons for the forecasts changes will be discussed in the presentation.