Priority Task

"**Con**solidation of the **S**urface-to-**A**tmosphere **T**ransfer-Phase 4:

(ConSAT4)

General Task:

- Implementing the next steps of consolidating
  - the **combined schemes** for
- **surface-to-atmosphere transfer SAT** including the **calculation of near surface variables**
- model for **moist turbulent statistics** **interacting with the statistics of non-turbulent SGS statistics** <-> **STIC**
- the generalized code for **vertical diffusion**
- the **heat budget of the roughness layer and its obstacles** including the **description of evapotranspiration**

content of module TURBDIFF

(small) part of TERRA-code

- **Improving the overall model performance** and particularly the **daily and annual cycles of near surface model variables** by an **iterative cycle of the following general actions**:
  i. Diagnostics by **component test** in order to detect potentials of improvement
  ii. Activation of **already implemented options**
  iii. Implementation of **further extensions and corrections** along a **dynamically adapted action list**, which is according to the strategy of the current **COSMO science plan**

Current state with the common TURBDIFF code:

- **Common blocked** COSMO/ICON TURBDIFF code implemented into COSMO
  - Including a **couple of extensions** and generalizations with regard to **SAT** and the **turbulence model**
  - Including a **generalized formulation** of **vertical diffusion** applicable
    - for all full- and **half-level** variables
    - for gradient- and **non-gradient** fluxes

    including **wind components**, all **active and passive scalars** and **tracers** and **statistical moments**
  - **Verified in several parallel experiments** with COSMO-DE (including also the **blocked version of vertical diffusion**
    - called (with the exception of statistical moments) **at the end of the physics section**
    - called for each **staggered horizontal wind component** (in contrast to ICON)

Related new Tasks:

Regarded to the general design of the common turbulence code the following actions need to be **transferred from the previous phase**:

WP I: Shifting all remaining **surface layer calculations** from the atmospheric part **into the surface layer part** [in order to allow for a better application of **surface tiling**, makes the code more clean]. **Ra: 0.05 FTE**

WP II: Implementing **optional metric correction terms** into common blocked routine for vertical diffusion

[only required for running **3D-turbulence** with this code, not really urgent] **Ra: 0.05 FTE Ba: 0.05 FTE**

Further, some development related to the **moist extension** is in the queue (since long), promising a **more consistent design of turbulent diffusion for the different sets of model equations of COSMO and ICON** and of the **cloudy boundary layer** in general:

WP III: Preparing **diffusion of the conserved variables** (total water content and total water potential temperature) and transforming the tendencies into those needed in the respective models (ICON or COSMO) by means of saturation adjustment

[desired for ICON with priority] **Ra: 0.05 FTE**

WP IV: Including ice-processes by **introducing a mixed water- and ice-cloud** into the turbulence code

[desired also for **T2(RC)2**] **Ra: 0.05 FTE**

Due to the expressed urgent requirements, we also include:

WP V: documentation of the whole package

[management requirement] **Ra: 0.1 FTE**

Current state with the diagnostics of SAT for stable stratification:

- **SC component tests** for investigation of the **stability dependency** of the Prandtl-layer part of **atmospheric transfer resistances for scalars** r_{S0}^{H} :
  - **Combined approach for SAT** (employing the STIC turbulence model rather than MOS) offers the possibility to **include additional processes of the stable boundary** into the SAT formulation
  - Currently **some interaction terms** are missing and **substituted** either by **crude approximations** (current thermal circulation term) or by **simple numerical security constraints** (minimal diffusion coefficients)
    - **too much nocturnal near surface mixing** for grid cells with a **homogeneous surface**
    - the consideration of a **special interpolation function of the transfer layer turbulent velocity profile** (**TTVP**) for **stable stratification** (necessary for being consistent with the utilized turbulence scheme) has almost **no effect** due to the additional mixing
  - The **combined SAT-scheme** of TURBDIFF is **reducible to the well established solution for a homogeneous surface**, **if**
    - these so far non-adaptive (on average beneficial but for a homogeneous surface unphysical) constraints are switched off
    - and the special TTVP for stable stratification is applied
    - and a so far implemented restriction of a transfer layer stability parameter is reduced

Already implemented first consequences:

- Implementation of the **optional stable branch of the TTVP**
- **Ri-number dependent modulation** of the crucial minimal turbulent diffusion coefficients '**tkhmin**' and '**tkmmin**' [had already been done within ICON]
- Modulation of the previously constant parameter '**pat_len**' of the current **thermal circulation term** in terms of the **standard deviation of SSO height** [had already been done within ICON]

Related new Tasks:

WP VI: **testing and varying the new extensions** together with an activation of the since long available **Deardorff-limit of the turbulent length scale** in **combination** with the **activation of the stable branch of TTVP** and the **relaxed restrictions for the transfer layer stability parameter**

[promising natural testing step as a **result of previous phase**]. **NN: 0.05 FTE**

WP VII: trying to find an even **better adapted statistical parameterization for the minimal diffusion coefficients** [natural and promising consequence but possibly a **more elaborate methodology** of setting up **statistical parameterizations necessary <-> CALMO**] **NN: 0.15 FTE**

WP VIII: trying to **reformulate the 'pat_len'-dependent STIC-term** (the near surface "circulation term") to be **better adapted to density flows along SGS slopes**

[natural and promising **consequence form last phase**] **Ra: 0.10 FTE**

WP IX: **investigating the effect of thermal surface patterns** that would results from **implemented surface tiles** by means of **idealized LES simulations** with the aim of later describing a **related SGS thermal circulations** by an adapted parameterization

[already started **basic investigation** of the significance of not yet properly represented SGS process] **Ce: 0.20 FTE**

The **success of performed SC component tests** (with regard to the stability dependency of the Prandtl-layer resistances) and **recent diagnostics** of the diurnal cycle of T2m/Td2m encourages us to the following next step:

WP X: completion of the **vertically not resolved roughness layer representation** (based on a generalized BLA) which has resulted in a **SAI-dependent resistance formulation** (substituting a specific roughness length for scalars): Introduction of the **roughness layer heat budget** by linearization of LRF and LHF and investigation of related **(global and local) parameters** (rlam_heat, rat_sea, c_land, c_soil, LAI **e_surf, dep_d, dep_v**)

[important and very promising step of consolidation] **Ra: 0.15**