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| **2D fields** |

**Hourly**

* Total precipitation (TOT\_PREC)
* Large-scale and convective snowfall (SNOW\_GSP & SNOW\_CON) 🡪 add in post-processing
* 2m temperature (T\_2M)
* Specific humidity (QV\_2M)
* Surface pressure (PS) 🡪 compute relative humidity and dewpoint temperature (if needed)

**Hourly 🡪 postprocess to monthly diurnal cycles**

* Average surface energy balance fluxes:
  + Sensible heat (ASHFL\_S), latent heat (ALHFL\_S),
  + Net downward SW (ASOB\_S), downward direct SW (ASWDIR\_S), downward diffuse SW (ASWDIFD\_S) 🡪 redundant: upward SW (ASWDIFU\_S)
  + Net downward LW (ATHB\_S), downward LW(ATHD\_S) 🡪 redundant: upward LW (ATHU\_S)
* CAPE (CAPE\_ML), CIN (CIN\_ML)
* Surface evaporation (AEVAP\_S)

**3-hourly**

* Mean sea level pressure (PMSL)
* Total cloud cover (CLCT), Low, medium and high cloud cover (CLCL, CLCM, CLCH)
* Ground temperature (T\_G)
* 10m wind (U\_10M, V\_10M)
* Surface albedo (ALB\_RAD)
* Average top of atmosphere fluxes:
  + Net downward SW (ASOB\_T), Downward SW (ASOD\_T)
  + Outgoing LW (ATHB\_T)
* Precipitable water (TQV), Vertical integrated cloud water (TQC), vertical integrated cloud ice (TQI), Total water content (TWATER)
* Total zonal/meridional water flux (TWATFLXU, TWATFLXV)
* Height of the boundary layer (HPBL)
* Atmosphere water divergence (TDIV\_HUM)

**Daily**

* 10m wind speed maximum (VMAX\_10M)
* Snow water equivalent (W\_SNOW), Snow depth (H\_SNOW), Snowmelt (SNOW\_MELT)
* 2m minimum/maximum temperature (TMIN\_2M, TMAX\_2M)
* Duration of the sun (DURSUN)
* (Sub-)surface runoff (RUNOFF\_S, RUNOFF\_G)
* Soil water content (W\_SO) 🡪 possible to output vertically integrated value?

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| **3D fields** |

**3-hourly (150, 200, 300, 400, 500, 600, 700, 850, 925, 1000 hPa)**

* Zonal, meridional and vertical wind (U, V, W)
* Specific humidity (QV), Temperature (T), Geopotential (FI)

**6-hourly 🡪 postprocess to daily mean**

* Soil temperature (T\_SO) 🡪 Top two + bottom layers

**Daily**

* Total diabatic heating (temperature tendency, temperature vertical diffusion, solar heating rate and longwave heating rate) (daily average respectively accumulation):
  + Solar radiation heating rate in the atmosphere (SOHR\_RAD)
  + Thermal radiation heating rate in the atmosphere (THHR\_RAD)
  + Convective tendency of temperature (DT\_CON)
  + Tendency of t due to SSO (DT\_SSO)

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| **Miscellaneous notes** |

**Test**

* Production of 4.4 km simulation works with boundary cropped boundary data
* Check if radiation components at surface add up 🡪 if so, remove redundant variables from output list

**Open questions**

* Imamovic et al. (2019) 🡪 experiments with 1 km spacing 🡪 use 2 km (instead of 4.4 km) for envelop topography experiment (but run maybe less than 10 years?)

**Optional output variables**

* TQR, TQS, TQG

**Miscellaneous**

* Monthly restart files 🡪 e.g. used to run for case-study and output additional variables (or at higher resolution...)

**Glacier model input**

* Open Global Glacier Model: monthly temperature and precipitation
* Global Glacier Evolution Model (GloGEM): monthly temperature and precipitation

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| **Variables used in relevant studies** |

**3D fields**

* Horizontal wind @ different pressure levels
  + **850 hPa**, SLP: Zhang et al. (2015)
  + 200, 500 hPa : Sabin et al. (2013)
  + 700 hPa: Dong et al. (2018)
  + 1000 hPa: Liu et al. (2015c)
* Temperature @ different pressure levels
  + Average 200 - 600 hPa: Deplazes (2021)
  + 500 hPa: Zhang et al. (2015)
  + 250 hPa: Molnar et al. (2010)
* Vertical velocity
  + 500 hPa: Zhang et al. (2015), Dong et al. (2018)
  + Various elevations/pressure levels: Liu et al. (2015b)
* Geopotential height
  + 500 hPa: Paeth et al. (2019)
  + 200 hPa: Dong et al. (2018)
* Vertically integrated water vapor transport [kg m-1 s-1]: Zhang et al. (2015)
  + Zonal/meridional wind (u, v), specific humidity (q), pressure (p) 🡪 integration from 1’000 to 300 hPa: Guan et al. (2019), surface pressure to 100 hPa: Dong et al. (2018)
* Water vapor flux and wind convergence in the lower (below 500 hPa) troposphere: Kitoh et al. (2017)
* Total precipitation water (TPW): Zhang et al. (2015) 🡪 probably the same as total precipitable water (🡪 vertically integrated specific humidity): Sabin et al. (2013)
* Divergence: Sabin et al. (2013)
* Vorticity: Sabin et al. (2013), Dimri et al. (2013), Wang et al. (2017), Xiao et al. (2016), Wei et al. (2015a)
* Total diabatic heating
  + Huber et al. (2012): vertical cross-section; averaged over winter/summer; diabatic heating is calculated by adding the heating sources (temperature tendency, temperature vertical diffusion, solar heating rate, longwave heating rate, and horizontal temperature diffusive heating [K/day]
  + Tada et al. (2016): vertical cross-section
  + Liu et al. (2020c): July mean
  + Acosta and Huber (2020): vertical cross-section; JJA mean
  + Zhang et al. (2018c): vertical cross-section; summer average; total diabatic heating: temperature tendency, temperature vertical diffusion, solar heating rate, and longwave heating rate
  + Chen et al. (2014e): vertical cross-section; average over year?
* Components of diabatic heating
  + Zhang et al. (2015): vertical cross-section; averaged over summer; total diabatic heating is calculated by adding the heating sources (temperature tendency, temperature vertical diffusion, solar heating rate and longwave heating rate); different components only mentioned in text
  + Zarrin et al. (2011): @700 hPa, averaged over summer, diabatic heating: local temporal derivative, horizontal/vertical advection
  + Panosetti et al. (2019: volume-averaged, diurnal cycle, total heat tendency: grid-scale advection, subgrid-scale sensible heat flux convergence, radiative flux convergence, contribution from microphysical processes 🡪 Langhans et al. (2012): budget-diagnosis tool in COSMO; COSMO newsletter 12
  + Xu et al. (2013a): vertical profiles, averaged over March, components: longwave, shortwave, T diffusion /vertical, horizontal), condensation heating, meridional heat transport
  + Shi et al. (2015): column heating rate [W/m2] (sum of radiative, sensible and latent heat fluxes) and temperature advection @850hPa; winter mean
* Diabatic/adiabatic heating
  + Xie et al. (2020): @500 hPa; averaged over 3 months
  + Sha et al. (2020): @400 hPa; averaged over summer?, diabatic heating, adiabatic heating, temperature advection

**Miscellaneous**

* Surface wind (10 m zonal/meridional): Paeth et al. (2019) 🡪 cluster analysis, Kitoh et al. (2010)
* Soil water content (0 - 10 cm, 10 - 40 cm): Halder et al. (2017)
* Dry static stability: Park et al. (2012)
* Equivalent potential temperature: Ma et al. (2014)
* Vertically integrated atmospheric water (vapor, cloud, ice, snow, graupel, rain): Imamovic et al. (2017/2019)
* Maximal updraft velocities, liquid water path, convective mass flux (Panosetti et al., 2016/2018/2019)
* Atmosphere water divergence, vertical integral divergence of humidity (Dimri et al., 2013; Huber et al., 2012; Xiao et al., 2016)
* Convective available potential energy (CAPE): Chen et al. (2014e)

**Variables that can be computed/estimated from output variables** (e.g. with MetPy)

* Omega (vertical pressure velocity) 🡪 estimate from vertical velocity
* Dewpoint 🡪 compute from pressure, temperature and specific humidity)
* Potential temperature 🡪 compute from pressure and temperature
* Equivalent potential temperature 🡪 compute from pressure, temperature and dewpoint
  + Applied in Ma et al. (2014), Shrestha et al. (2015), Acosta et al. (2020)
* Height 🡪 compute from geopotential
* Moist static energy 🡪 compute from height, temperature and specific humidity
  + Applied in Sabin et al. (2013)
  + Similar to equivalent potential temperature
* Precipitation minus evaporation (P-E) is balanced by time-averaged and column-integrated moisture flux 🡪 moisture flux convergence (Shi et al, 2019b)
* Air density (Imamovic et al., 2019)

**Variables not available in COSMO**

* Wave activity fluxes at 250 hPa (Wang et al., 2018c), 500 hPa (Zhang et al., 2017a) (m2 s-2)
* Eady growth rate at 850 hPa (Luo et al., 2015)
* Eddy (Seol, 2009)
* Eliassen–Palm flux (Wang et al., 2017g)
* 200-hPa zonal kinetic energy (Wang et al., 2017g)
* Stream function on pressure level (m2s-1) (Zhang et al., 2017a)
* Vertical moisture advection (VMFC) (Freychet et al, 2015)
* Jet core number @ 300 hPa (shaded; m s-1) (Luo et al., 2015)
* Dynamic/thermodynamic component (Tian et al. 2019)
* Low-level entropy (Equivalent potential on a terrain-following model level about 20 hPa above the surface) (Chen et al., 2014e), entropy (Boos and Kuang, 2010)
* Divergence (3D data) : Sabin et al. (2013)
* Dry static stability: Park et al. (2012)
* Temperature advection (horizontal; 500 hPa) (Tang et al., 2013b)

**Less relevant variables**

* Hourly output at 100 m (U, V)
* Average 10 m wind speed (VABS\_10M\_AV)
* Moisture convergence in the air for kuo type closure (QCVG\_CON)
* Clear-sky variables, stress quantities, averaged solar downward radiation at top (ASOD\_T)
* Moisture flux convergence/divergence (Wong et al., 2018; Freychet et al, 2015)
* Meridional temperature gradient (Wang et al., 2017g)
* Wind stress fields (Sepulchre et al., 2009)
* Water vapor flux divergence at specific pressure levels (700 hPa; Xie et al., 2021)
* Vertically integrated water vapor transport (Zhang et al., 2018c) 🡪 moisture flux available
* Mean water vapour transport & divergence (Yu et al., 2018) 🡪 moisture flux and water vapour divergence available