A Long-term Hindcast simulation with COSMO-CLM² over Antarctica

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COSMO-CLM\(^2\)

- **COSMO**: non-hydrostatic atmospheric model (Rockel et al., 2008)
- **CLM**: climate mode
- **CLM**: coupled to the Community Land Model 4.5
- boundary conditions: Era-Interim
- horizontal resolution: 0.22 degrees
- Antarctic Cordex domain
- 30 years run (1987-2016)
Validation against

- Automatic Weather Stations
- station measurements
- balloon measurements (Turner et al., 2004)
- SMB data (Favier 2013), ice core data (Thomas et al. 2017) and reconstruction from B. Medley (in prep.)

*Figure*: Location of the measurement sites (SCAR, IGRA)
Changes to COSMO

- boundary layer stability coefficients are lowered to get more stable boundary layer and better near-surface temperatures (Cerenzia et al., 2014)
- upper air relaxation for better representation of the tropopause (van de Berg and Medley, 2016)
- implementation of the two-moment scheme + adaptations therein to get better SMB representation (Seifert and Beheng, 2008)
  - adaptations to homogeneous and heterogeneous nucleation (Köhler and Seifert 2015)
  - autoconversion threshold lowered (Ghosh and Jonas, 1998)
  - deposition coefficient lowered (Gierens et al., 2003)
Coupling to CLM 4.5

- adaptations backported from CLM 5.0 (van Kampenhout et al., 2017)
  - snow pack bug
  - wind compaction of snow implemented
  - radiation bug
- roughness length adapted to $10^{-5}$ (Smeets and van den Broeke, 2008) to represent better katabatic and wind speeds over ice shelves

**Figure:** Annual mean density in the uppermost snow model layer (1979-1998) for CLM4.5 and CLM5.0, from van Kampenhout et al., 2017
large scale atmospheric climatology

Temperature winter
large scale atmospheric climatology

Temperature summer
large scale atmospheric climatology

Wind speed
winter
large scale atmospheric climatology

Wind speed
summer
large scale atmospheric climatology

Relative humidity winter
large scale atmospheric climatology

Relative humidity
summer
surface climate

Temperature
Summer

COSMO-CLM²-OBS Season = DJF
surface climate
surface climate

Wind speed
Winter

COSMO-CLM$^2$-OBS Season = JJIA

Results

Conclusions
surface climate

Wind speed
Summer

COSMO-CLM²-OBS Season = DJF

Observations
surface climate

Figure: DJF albedo COSMO - MODIS
Surface Mass Balance

Comparison of SMB, 1983-2010
CCLM$^2$ versus Favier 2013 and Medley ice cores
point = mean of data, error bar = min and max vals

SMB CCLM$^2$ (kg/m$^2$ year)
SMB Favier and Medley (mm ice equ/year)

- 1:500 m asl, n = 7
- 500:1000 m asl, n = 5
- 1000:2000 m asl, n = 7
- 2000:3000 m asl, n = 17
- > 3000 m asl, n = 77
Surface Mass Balance

Cosmo SMB = snowfall - sublimation (- melt); integrated over 1987-2010

Figure: COSMO versus reconstructed surface mass balance
Conclusion and future work

- COSMO has been adapted adequately to represent the Antarctic climate
- 30 years run (1983-2017), contribution to the CORDEX effort
- future work:
  - radiation and turbulent fluxes
  - relative humidity at the surface
  - surface mass balance
  - nesting over smaller domain, at higher resolution (2.8 km)
  - clouds and aerosols interactions → snowfall
  - blowing snow scheme → SMB, wind speeds
References