Impact of Antarctica albedo changes in the ECMWF model

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The impact of a change in the specification of the permanent snow albedo during Antarctic summer is evaluated in a set of forecasts and data assimilation experiments with the ECMWF Integrated Forecast System. At those latitudes, with shallow planetary boundary layers, the snow albedo is a key parameter regulating the amplitude of the diurnal cycle in near-surface temperatures. Observations taken at Dome-Concordia confirm that an increase in albedo, (up to 0.80) as supported by recent studies, improved the match to the radiosondes temperature data, reducing the model warm bias. On a longer time-range the model's climate is affected both with a low-level cooling and with an increase in 10m wind speed over Antarctica extending onto the Southern Ocean.

Outlook

- Motivations (Antarctica surface T,U,V bias)
- A simple change in albedo
- Sensitivity in long integrations
- Sensitivity in short-term forecasts
- Impact on scores
- Conclusions

Motivations

- **A large bias in temperature and wind at DOME Concordia**

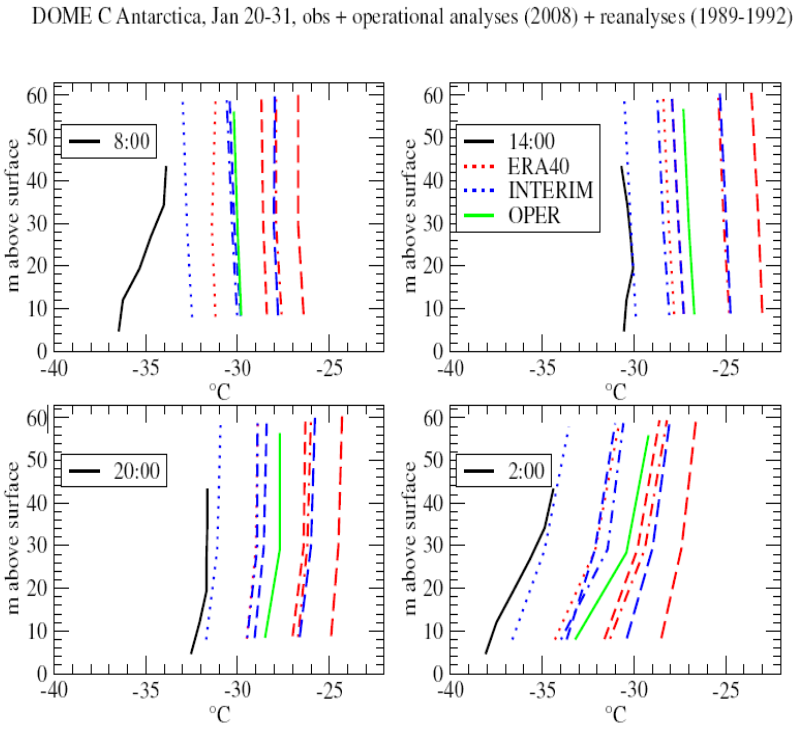


Figure 1: Temperature profile: tower observations (black), OPER analysis (green), ERA-40 (red, ... Interim (blue, 1989-1992). Courtesy of C. Genthon.

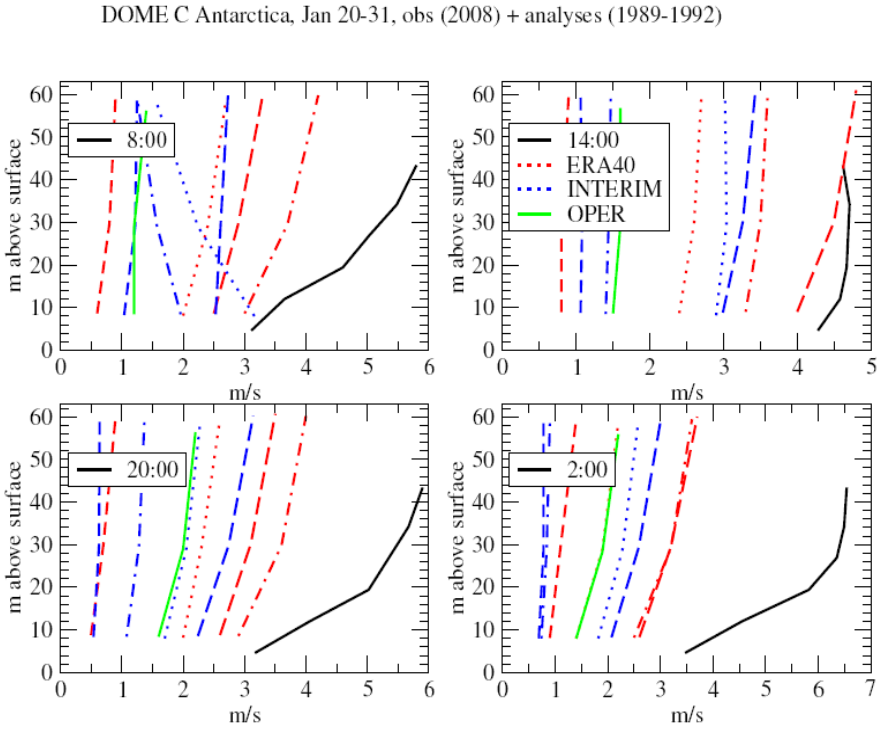


Figure 2: Wind profile. As in Fig. 1.

Antarctica snow studies

- **Although diurnal variations of albedo are present, indication that an albedo of 0.8 is applicable over Antarctica is provided by Pirrazzini (2004).**
- **This means a 5% increase in albedo from the operational setup.**
- **Idealized green-house models (2-layers) indicate that a 5% albedo change could lead to roughly 4 K on surface temperature (F.W. Taylor, 2005, Elementary climate physics, Oxford University press).**

Long integration (observed SSTs)

- **Sensitivity experiments show a largely localized impact on Antarctica**

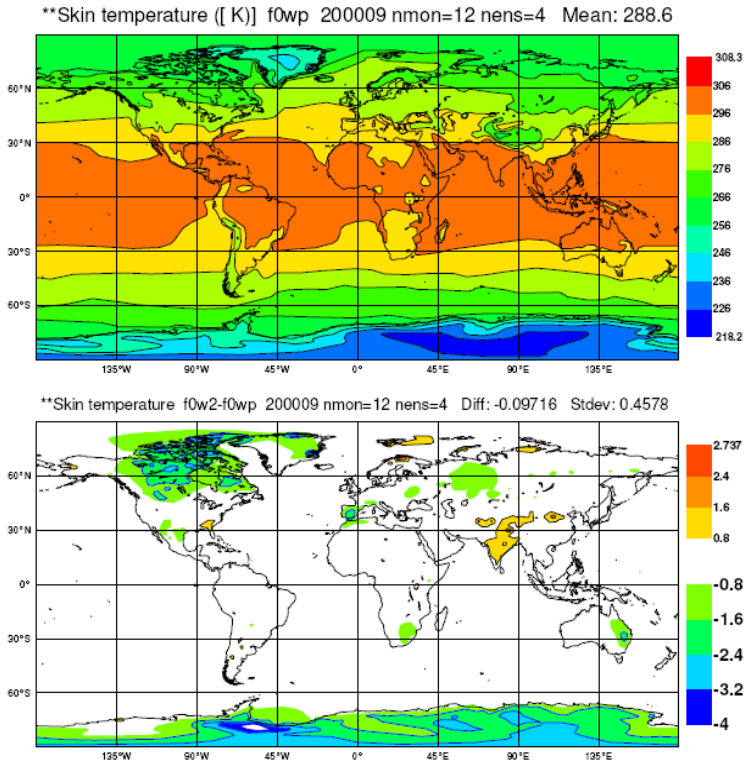


Figure 3: Impact of increased albedo in annual mean skin temperature.

Austral summer impact

2m temperature (4-6 K reduction) and wind (2-4 m/s increase) are affected

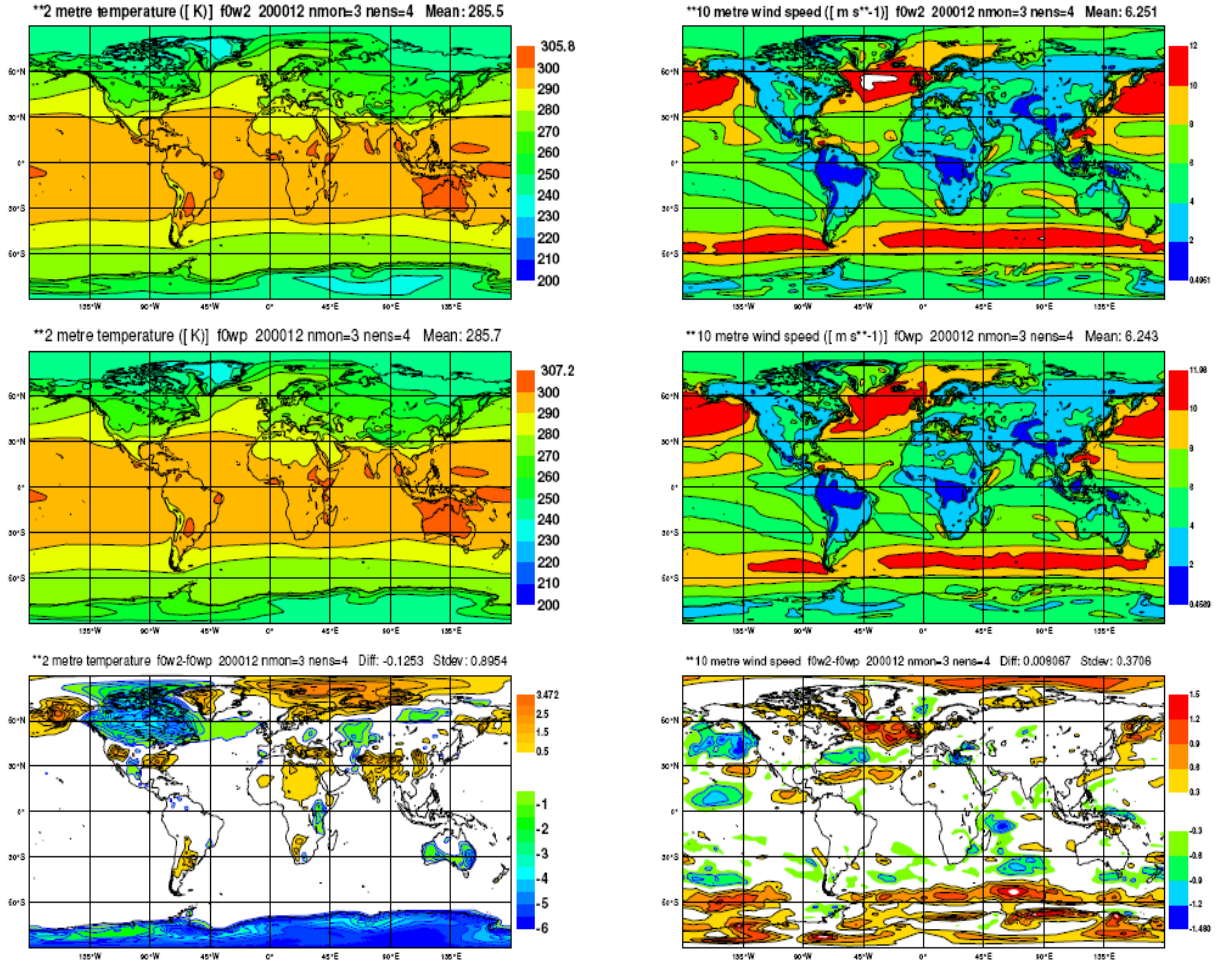
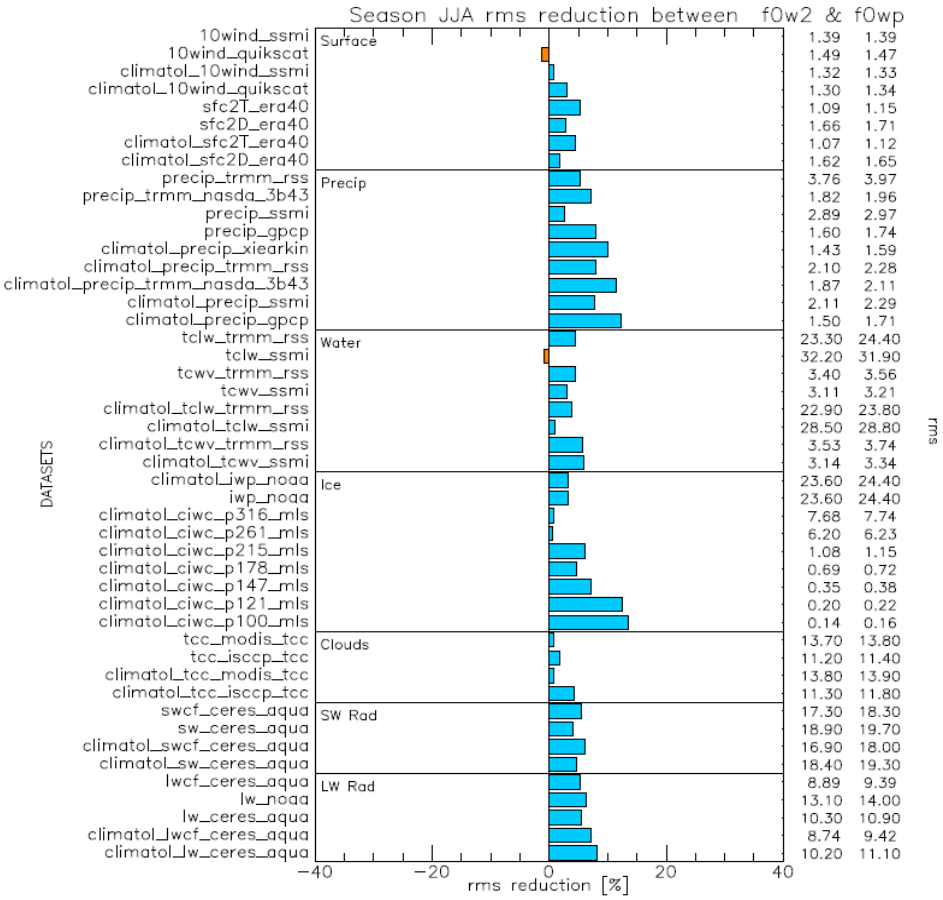


Figure 5: Impact of increased albedo in DJF 2m temperature (left) and 10m wind (right).

Overall climate impact

- **At the end of a “climate experiment” (13-month FC with specified SSTs) the verification indicates improvements in all the datasets used.**



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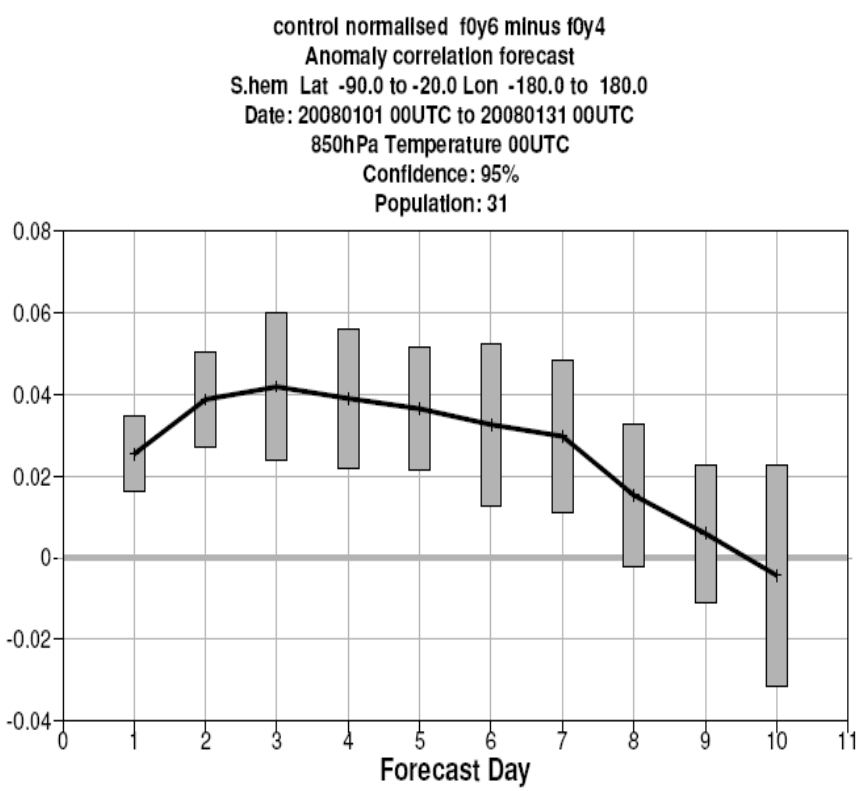
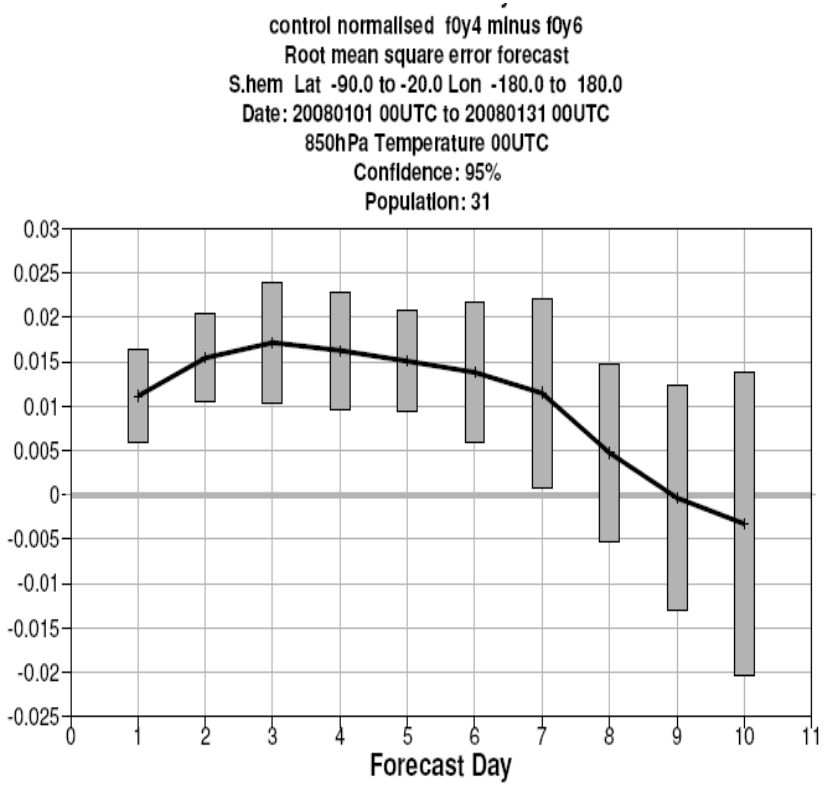
Forecasts impact

- **A set of 31 forecast of 10-days (Jan '08) shows T850hPa improvements in SH up to 4% in ACC (1.5% in RMSE) and significant up to 7-days**





Circulation impact on Antarctica

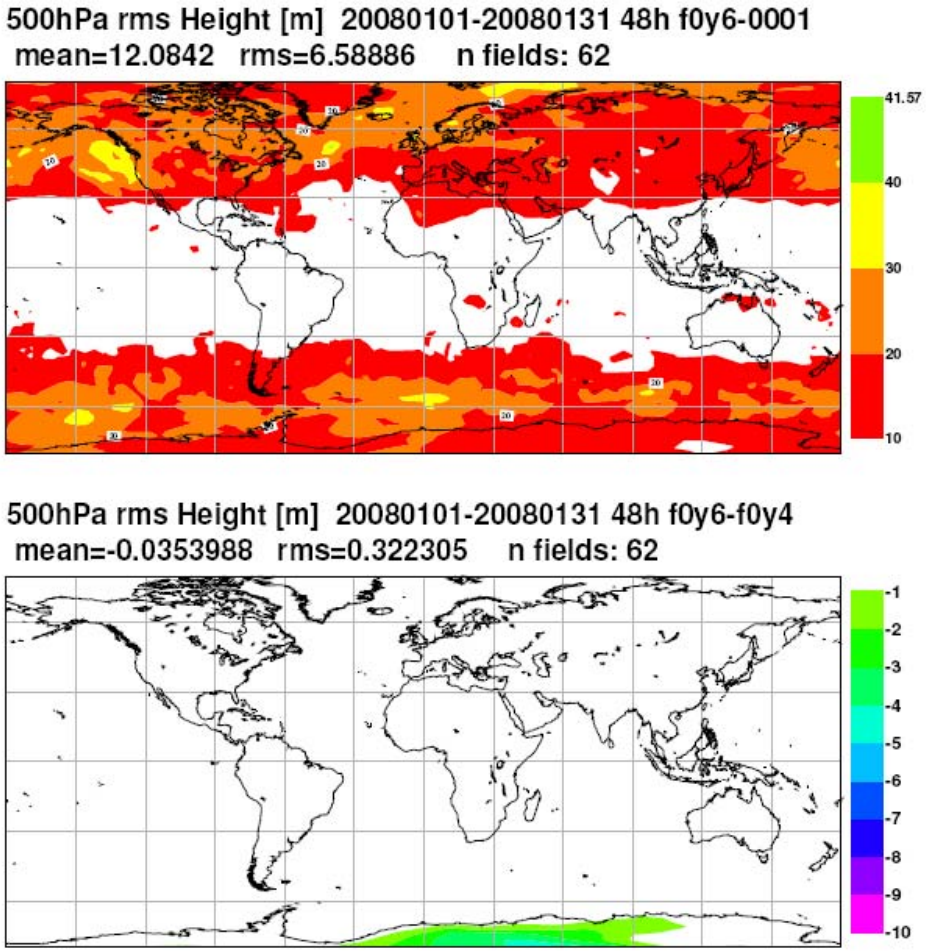


Figure 9: Mean RMSE difference (albedo Exp. – control CY33R1) for 500 hPa geopotential heigth (48-hour forecast) for January 2008, evaluated against the operational analysis

Impact on atmospheric T profile

- **Atmospheric profile responds to albedo whitening with a cooling very effective at the surface (here evaluated on a 48-h forecast).**

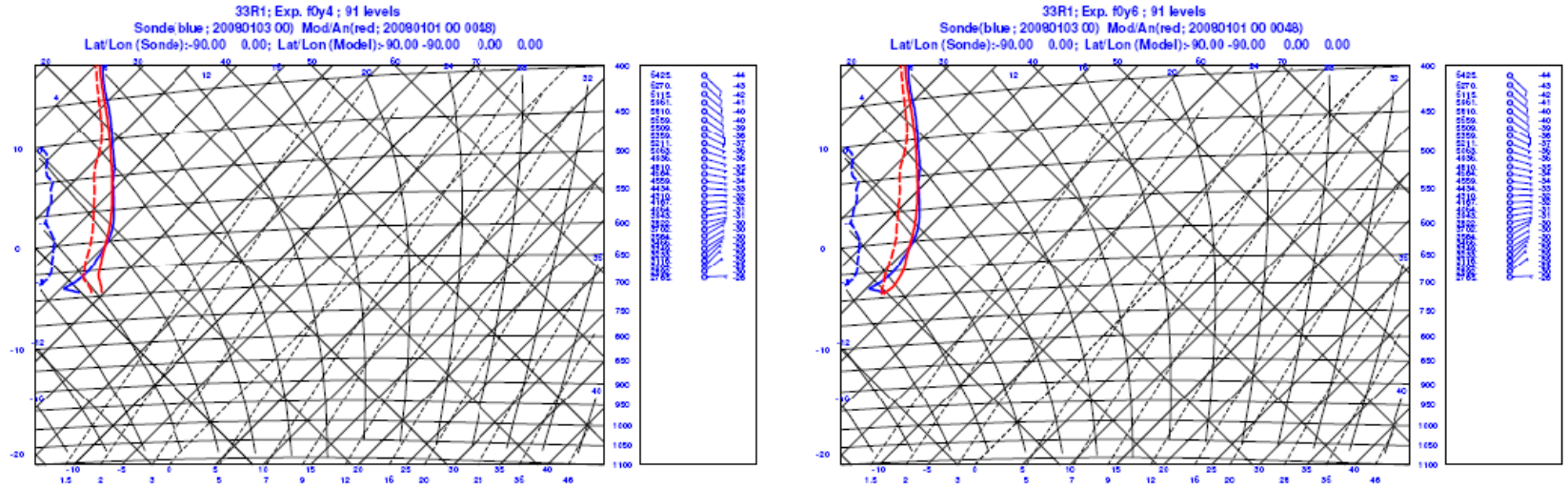


Figure 10: Averaged sounde profile for the South Pole station for January 2008 (blue) compared with averaged 48-hour forecasts (red): CY33R1 control (left) and increased permanent snow albedo experiment (right).

Conclusions

- **A simple albedo retuning for Antarctica has proven to be an effective constraint to model bias**
- **Impact is visible throughout the forecast range and in long integrations.**
- **The albedo change corrects the mean daily temperature (but there are still problems with diurnal cycle due to simple treatment of glaciers).**
- **Future revision of the snow scheme may improve on the diurnal cycle (multiple vertical layers allowing to resolve diurnal cycle variations).**

Outlook for the land surface model

2000/06	2007/11	2009/03	2009/09		2010

- **TESSEL**

  Van den Hurk et al. (2000)
  Viterbo and Beljaars (1995),
  Viterbo et al (1999)

  Up to 8 tiles (binary Land-Sea mask)

  GLCC veg. (BATS-like)

  ERA-40 and ERA-I scheme

- **Hydrology-TESSEL**

  Balsamo et al. (2009)
  van den Hurk and Viterbo (2003)

  Global Soil Texture (FAO)

  New hydraulic properties

  Variable Infiltration capacity & surface runoff revision

- **NEW SNOW**

  Dutra et al. (2010)

  Revised snow density

  Liquid water reservoir

  Revision of Albedo and sub-grid snow cover

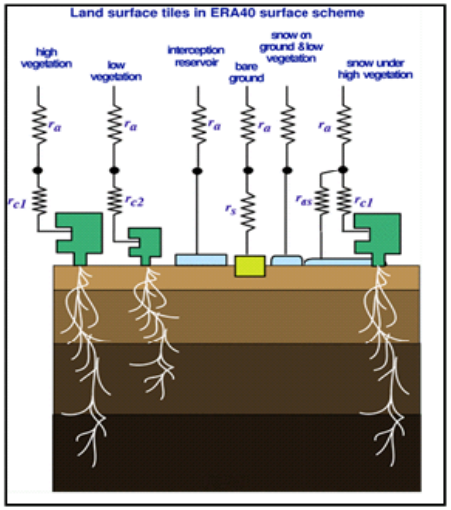
- **NEW LAI**

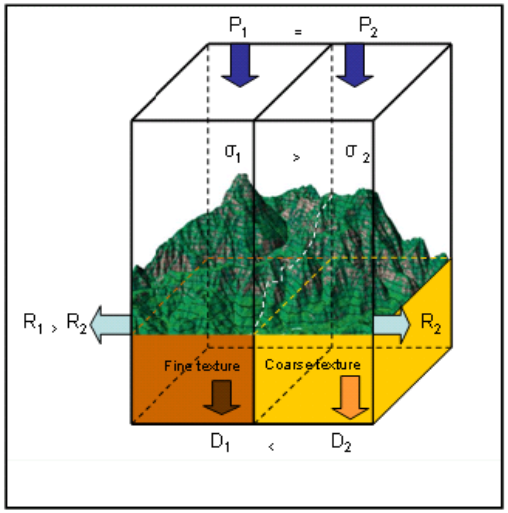
  Boussetta et al. (2010)

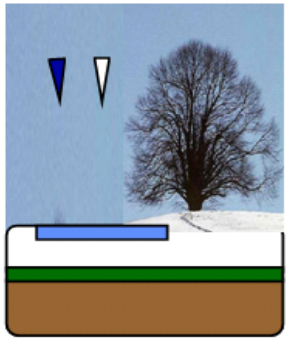
- **FLAKE**

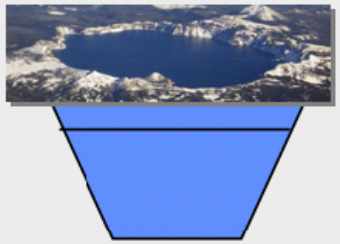
  Mironov et al (2010),
  Dutra et al. (2010),
  Balsamo et al. (2010)

  Extra tile (9) to account for sub-grid lakes









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