High resolution seasonal precipitation in a semi-arid complex terrain area using WRF-FDDA

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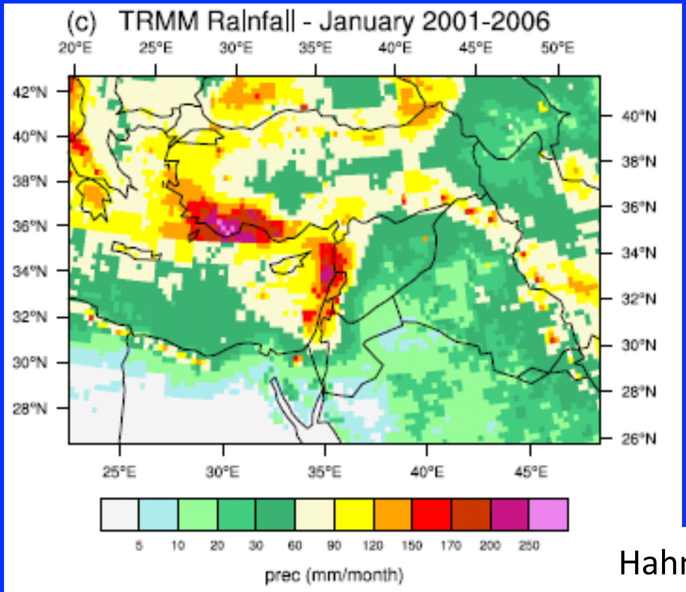
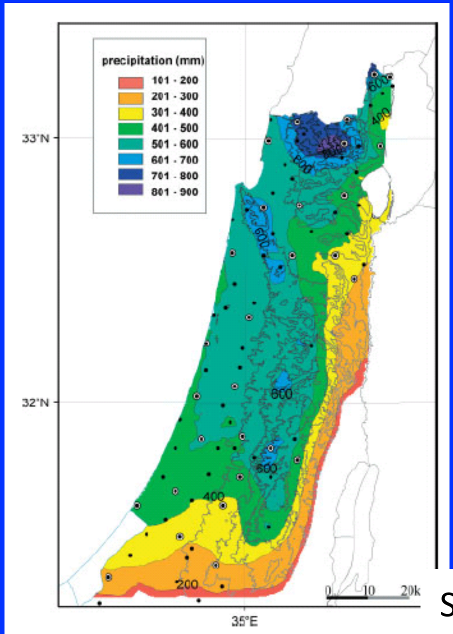
Motivation

The seasonal precipitation over the ***south-eastern Mediterranean*** shows **large spatial gradients** over a relatively small geographical area, due to:

- **large scale factors:** the preferred tracks followed by the extra-tropical cyclones and their intensity
- **mesoscale factors:** the local complex terrain, coastlines, and heterogeneous land properties



Hahmann et al., 2008



Saaroni et al., 2008

Motivation, cont.

- **Monitoring and prediction of the seasonal precipitation *are critical*** for estimating the amount of water that flows into water reservoirs.

- **Observational gaps** result from
  - uneven distribution of the observational network and
  - instruments failure.

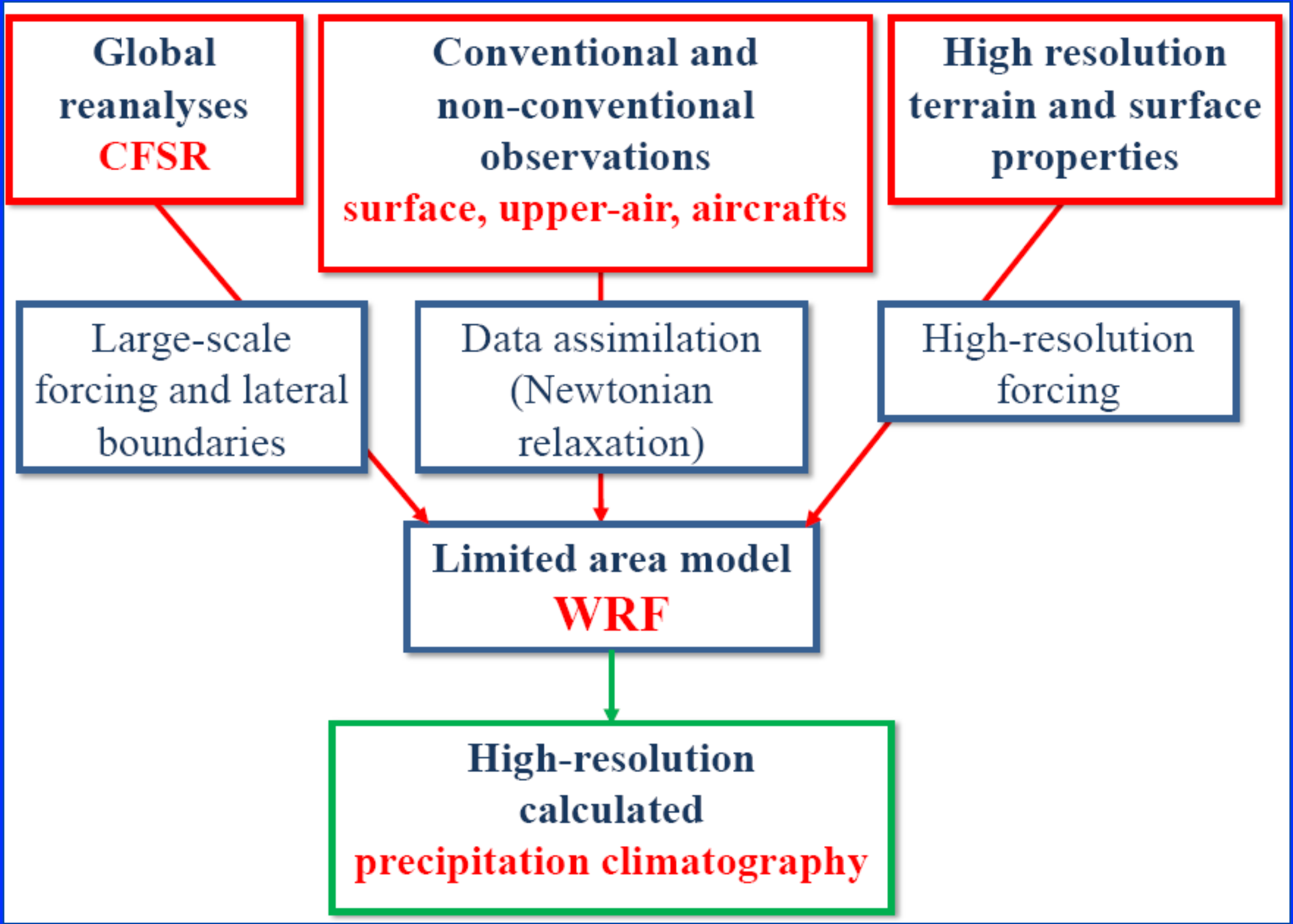
Our purpose

- Fill temporal and spatial gaps in past precipitation observations
- Improve statistical downscaling of global seasonal forecasts using simulated past seasonal precipitation at high horizontal resolution.

Method

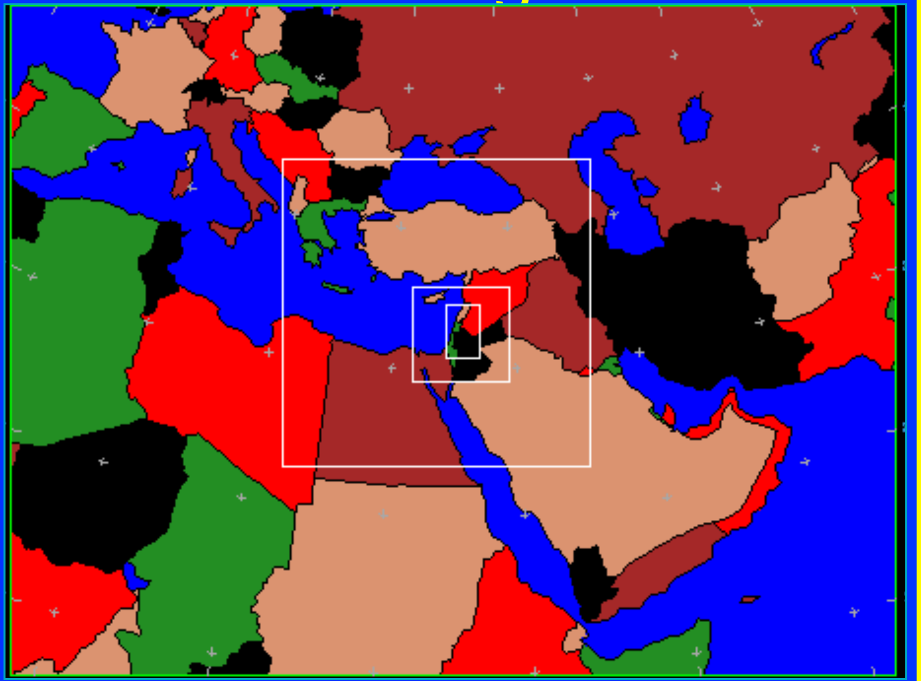
NCAR-RAL/WRF-FDDA system

(FDDA: Four Dimensional Data Assimilation)



Method: WRF-FDDA (re)analyses

WRF configuration



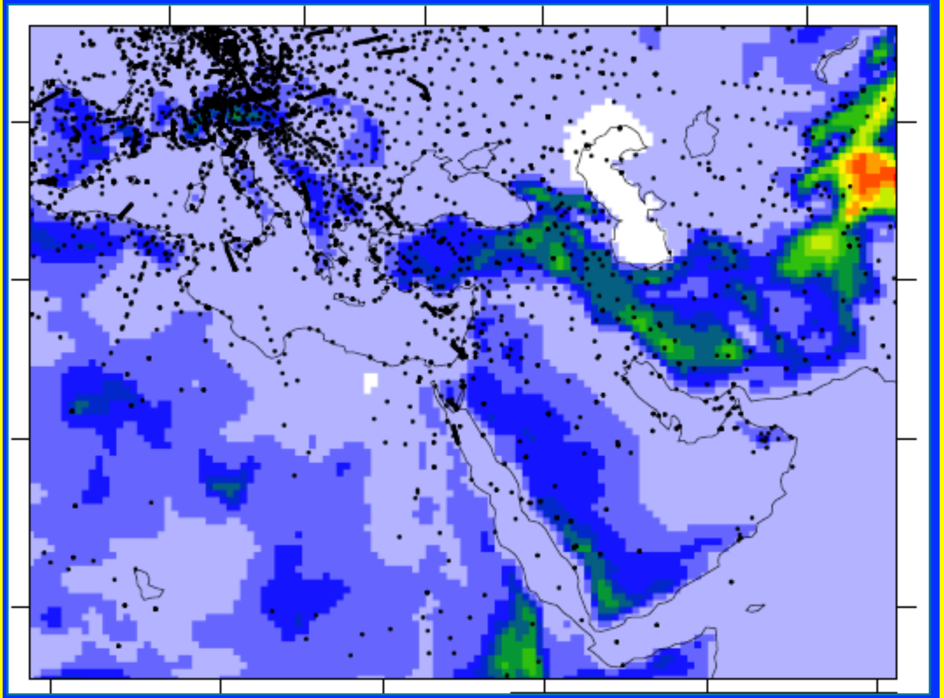
- 4 nested domains at 54, 18, 6 and 2 km grid spacing
- 37 vertical levels, 12 within the lowest 1 km
- Model top at 50 hPa.
- IC/LBC: NCEP's CFSR (0.5 degree)
- SST: 1/12th-degree RTGSST.

Physical parameterizations

Microphysics	Single-Moment 6-class cloud-particles
Cumulus	Grell-Devenyi
Radiation	RRTM and Dudhia
PBL	YSU
LSM	Noah

Observations assimilation

Snapshot of the spatial distribution of assimilated observations.



•Proven improvement of the analyses over this area when Newtonian-relaxation assimilation of observations is implemented (Hahmann, *et al*. 2010).

•Observations from NCAR's ADP/CISL-DSS.

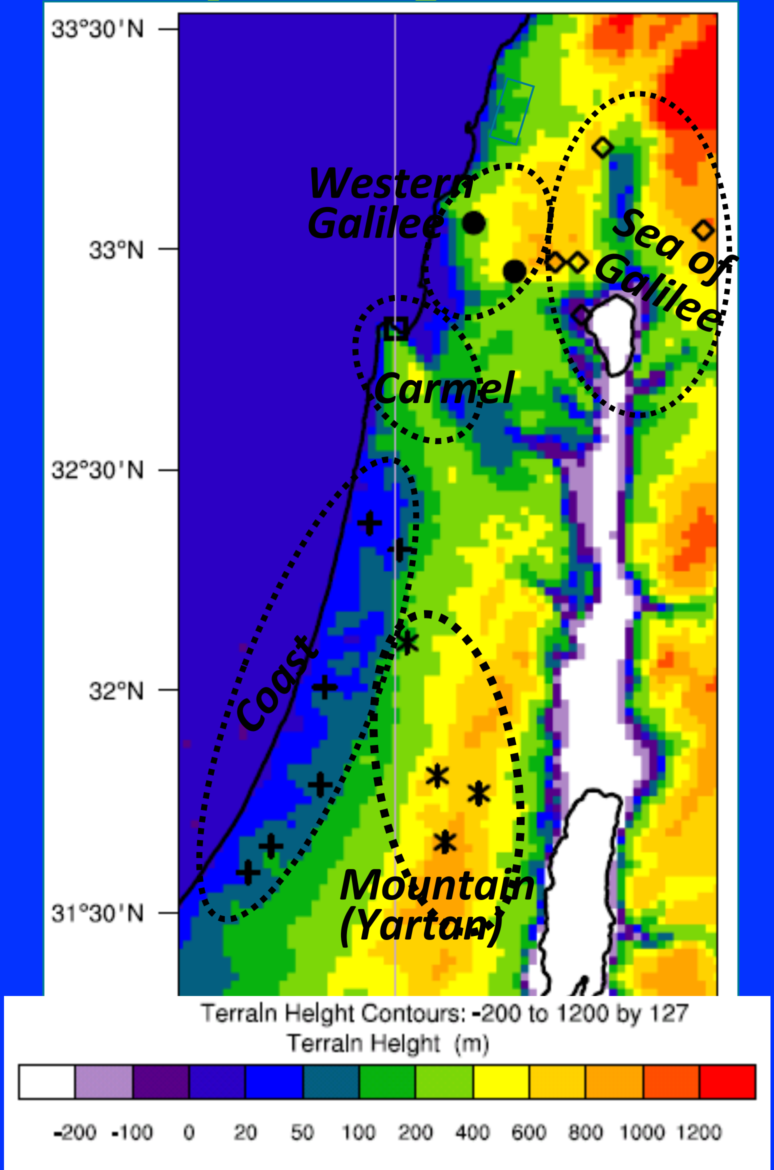
- Surface: SYNOP and METAR land reports (a few ship observations).
- Upper-air: radiosonde soundings and aircraft reports.

•Cold-start initialization every 4 days with one day overlap (first day discarded due to mode spin-up):

- minimizes error growth, particularly for areas with sparse observations.
- allows for simultaneous integrations for various time periods.

Verification strategy

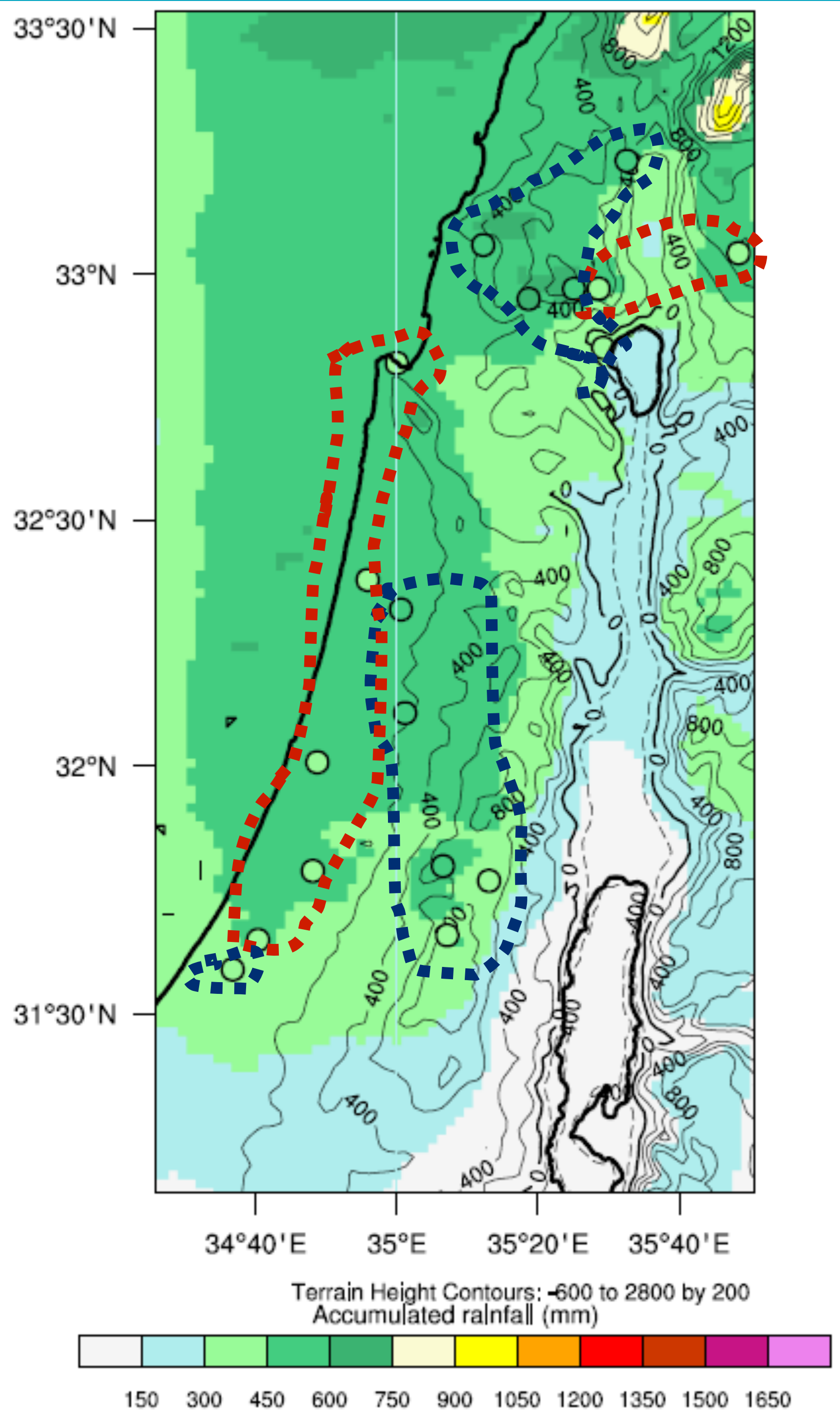
18 reliable rain gauges
at 5 hydrological basins



7 cold seasons

<u>December-January February (DJF):</u>

- 2008-2009
- 2007-2008
- 2006-2007
- 2005-2006
- 2004-2005
- <u>1998-1999 - dry extreme</u>
- <u>1991-1992 - wet extreme</u>



Results:

Multi-season mean spatial variability

•Good reproduction at all wetter locations, and at some drier locations, in particular over complex terrain.

•Overestimation by one category in our scale at most stations along the Coast-Carmel basins, and at two sites in the Sea of Galilee basin.

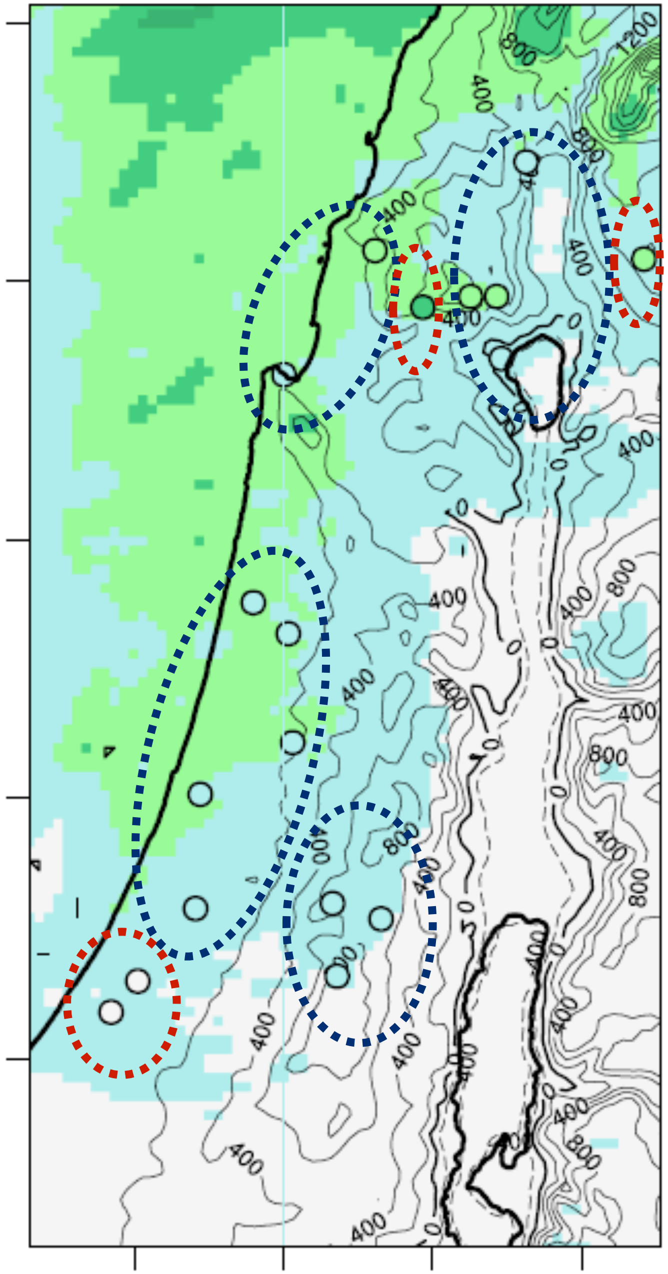
•Correct category may be shifted as little as one or two grid-points.

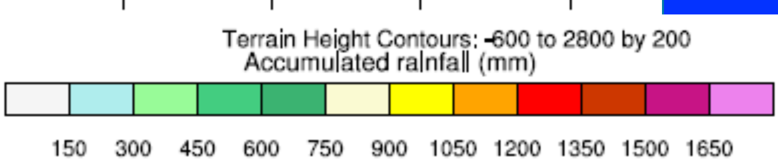
•Best agreement mostly over complex terrain: benefit of high-resolution lower-boundary forcing in the dynamical downscaling process.

•Possibly need for better SST data to further improve coastal precipitation.

Results: Inter-season variability

Driest DJF, 1998-1999





- Best agreement between model and observations in basins with complex terrain: Western Galilee, Carmel, Sea of Galilee, and Yartan; and most of flat Coast.

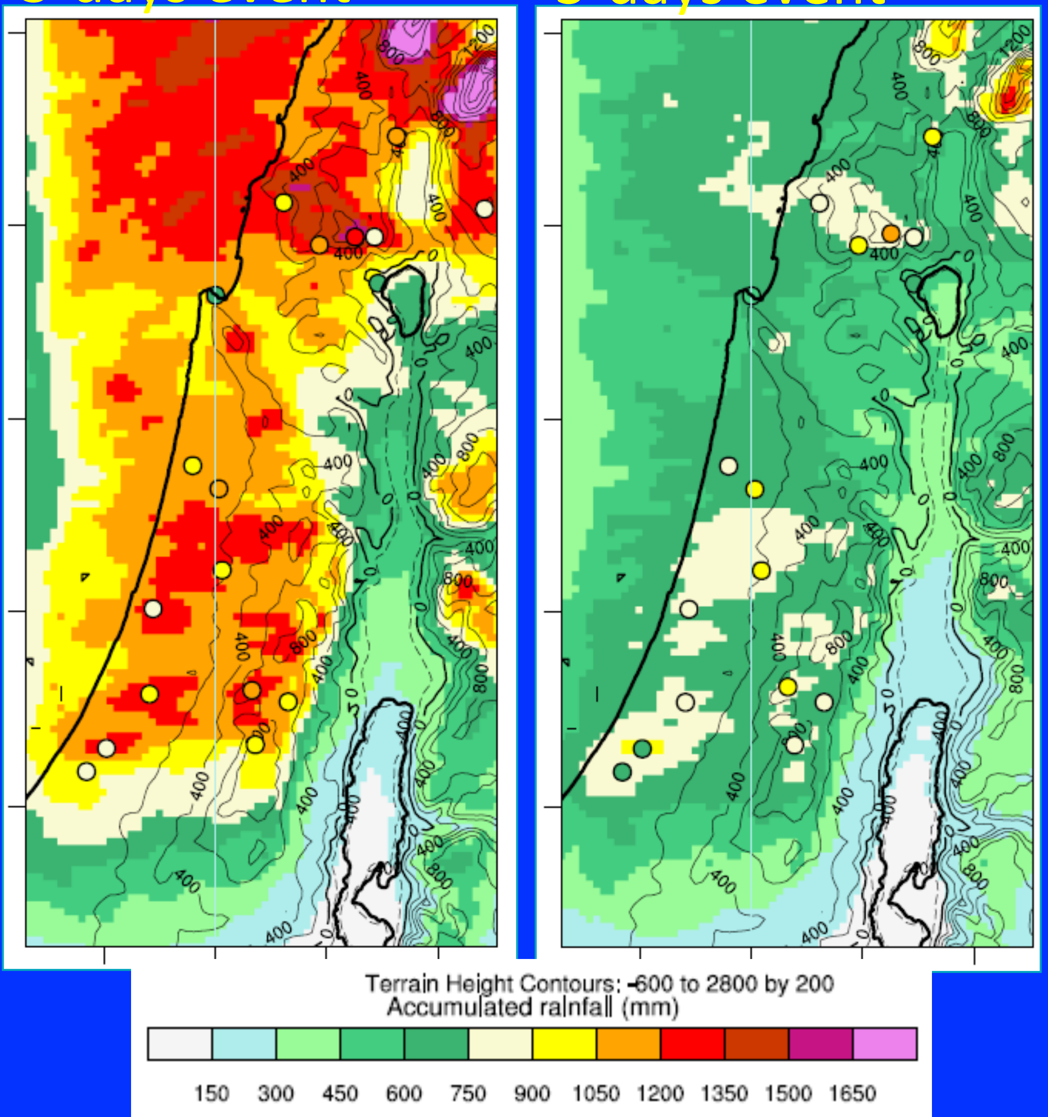
- At some stations the model tends to somewhat overestimate the observed precipitation (no more than one category in our scale).

Overall, the driest simulated season, 1998-1999, was well reproduced by the model.

Results: Inter-season variability-Wettest DJF, 91-92

Including rainiest 3-days event

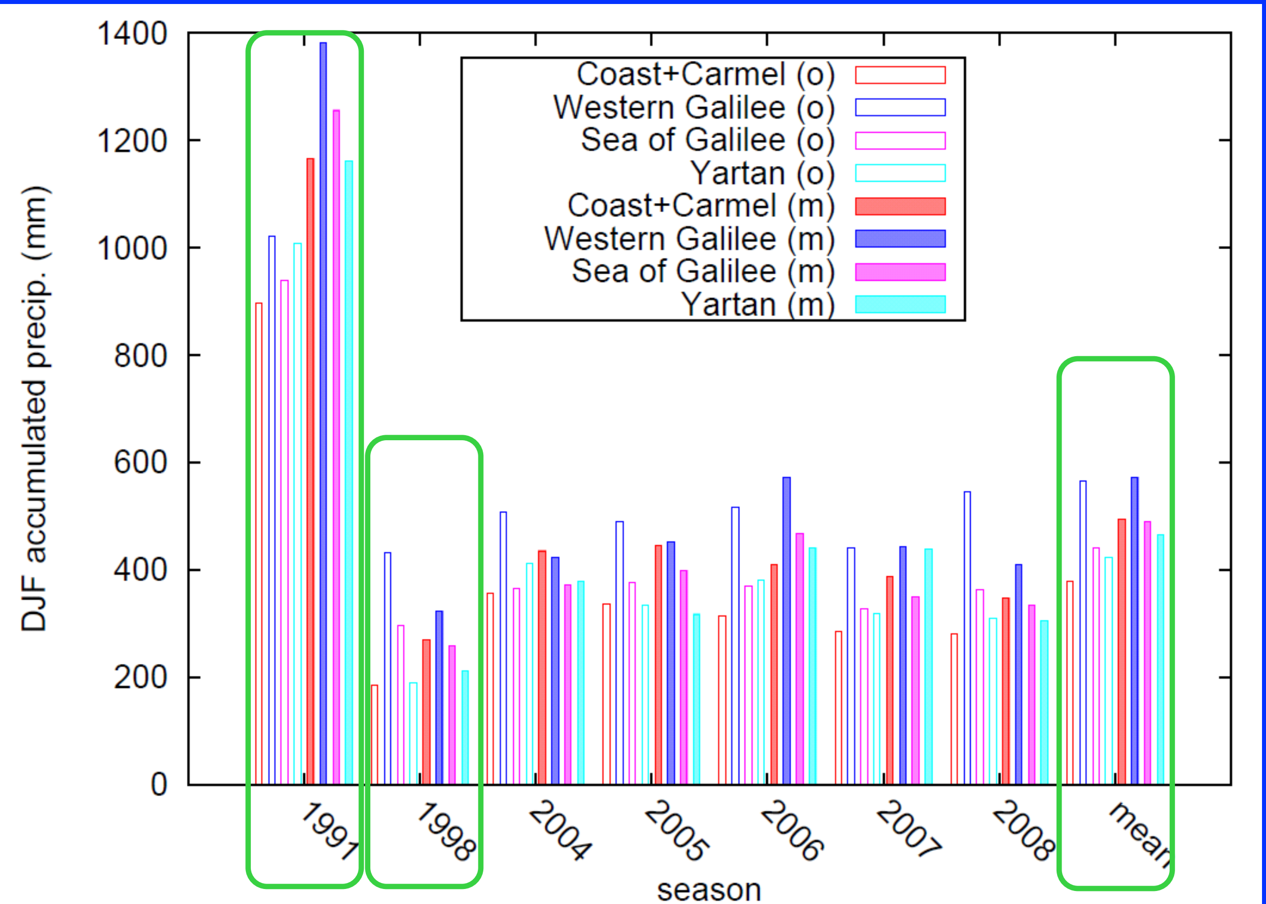
Excluding rainiest 3-days event



- One of the wettest recorded seasons.
- Nov 28th - Dec 3rd 1991: the rainiest spell recorded in 45 years.
- The difference between the figures illustrates the intensity of the event.
- Agreement between model and observations notably improved by excluding the rare event.
- Further study of the rare event is needed.

Results: Mean variability among basins

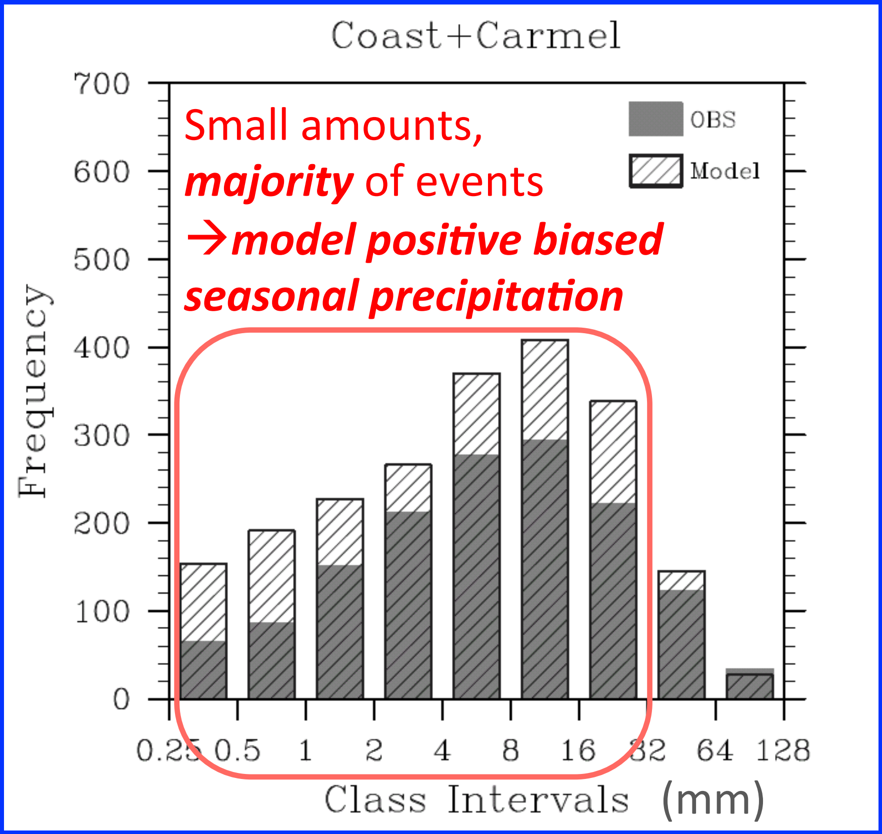
Observed and model DJF-precipitation at individual basins

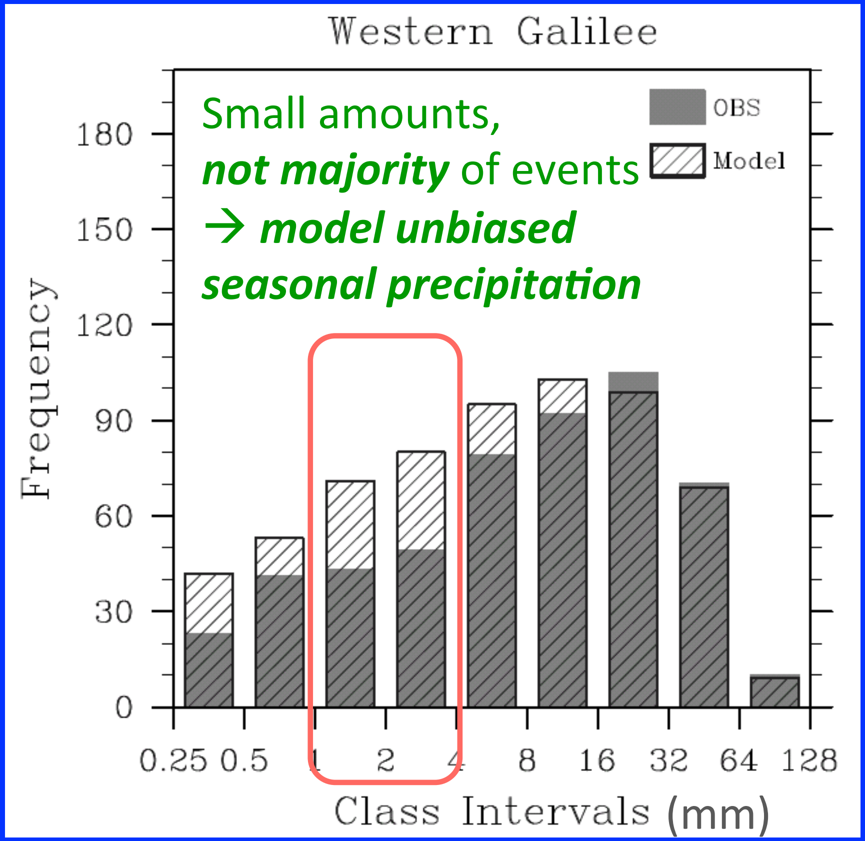


Best model-observations agreement for the Sea of Galilee and Yartan basins, both inland and complex terrain.

- **Model seven-year mean** reproduces intensities and gradients among the basins.
- **Outstanding wettest season (1991)** well captured but model overestimates due to rare event during Dec.
- **Driest season (1998)** in fair agreement with observations for all basins.
- **Model positive bias in Coast+Carmel basin**, but no systematic bias for the rest of the basins (all seasons).
- In general, larger gradients among basins in the observations (except 1991).

Results: Observed and model distribution of daily rainfall totals





- Largest differences in the Coast+Carmel basin lead to model positive bias.

- Western Galilee basin: main differences in the categories 1-4 mm daily totals. These are only few events and contribute with small amounts → excellent agreement between model and observed seasonal precipitation

Summary and conclusions

- Our simulations fairly reproduced the spatial and inter-annual variability of the seasonal precipitation.

- Best agreement between model and observations is found over complex terrain, illustrating the benefit of the high-resolution lower-boundary forcing in the dynamical downscaling process.

- Some biases were observed over coastal flat terrain, dominated by large scale forcing and suggesting the need for better representation of SST.

- The model exhibited limitations in reproducing rare events, suggesting the need of further tuning/different model configuration.

- Weather-regimes verification: biases are larger at coastal-flat areas under shallow-cyclonic conditions; deep-cyclonic conditions lead to more significant biases in complex-terrain regions. (**Poster 73**)

D. Rostkier-Edelstein, Y. Liu, W. Wu, P. Kunin, A. Givati, M. Ge., 2013: Towards a high-resolution climatography of seasonal precipitation over Israel. *Int. J. Climatol.* Accepted with minor revisions.

Thanks