Comparing the Sensitivity of ICON-IMS in Reference to Greek SYNOP Observations for Short and Long Range Lead Times

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WORK OVERVIEW

- The goal of this effort is to gauge the sensitivity of ICON model over a large number (**24**) of parameters towards the establishment of ICON-LEPS in place of the currently operational COSMO-LEPS.
- The consequent list of the parameters considered of interest for the corresponding perturbations in ICON-LEPS has been decided and ranked according to their estimated signicance by ICON experts, (*Schlemmer etal*, www.cosmo-model.org/content/support/icon/tuning/icon-tuning.pdf).
- All the parameters are tested over 88 Greek Meteorological stations for a total of 850016 observations for the year 2020 using the ICON model installed by the Israeli Meteorological service (IMS) at ECMWF over a domain covering the wider area of Greece and Italy and using computational resources provided gratis by the Hellenic National Meteorological Service (HNMS).
- The model sensitivities are presented for 7 surface fields over all station-average of the whole period for the shortest (1^{st} or 2^{nd}) as well as the longest 5^{th} lead day of the model runs in order to display any dependence on the range of the forecast.

SENSITIVITY TESTS BLUEPRINT

24 parameters are considerd.

$\otimes$

3 values/parameter including default.

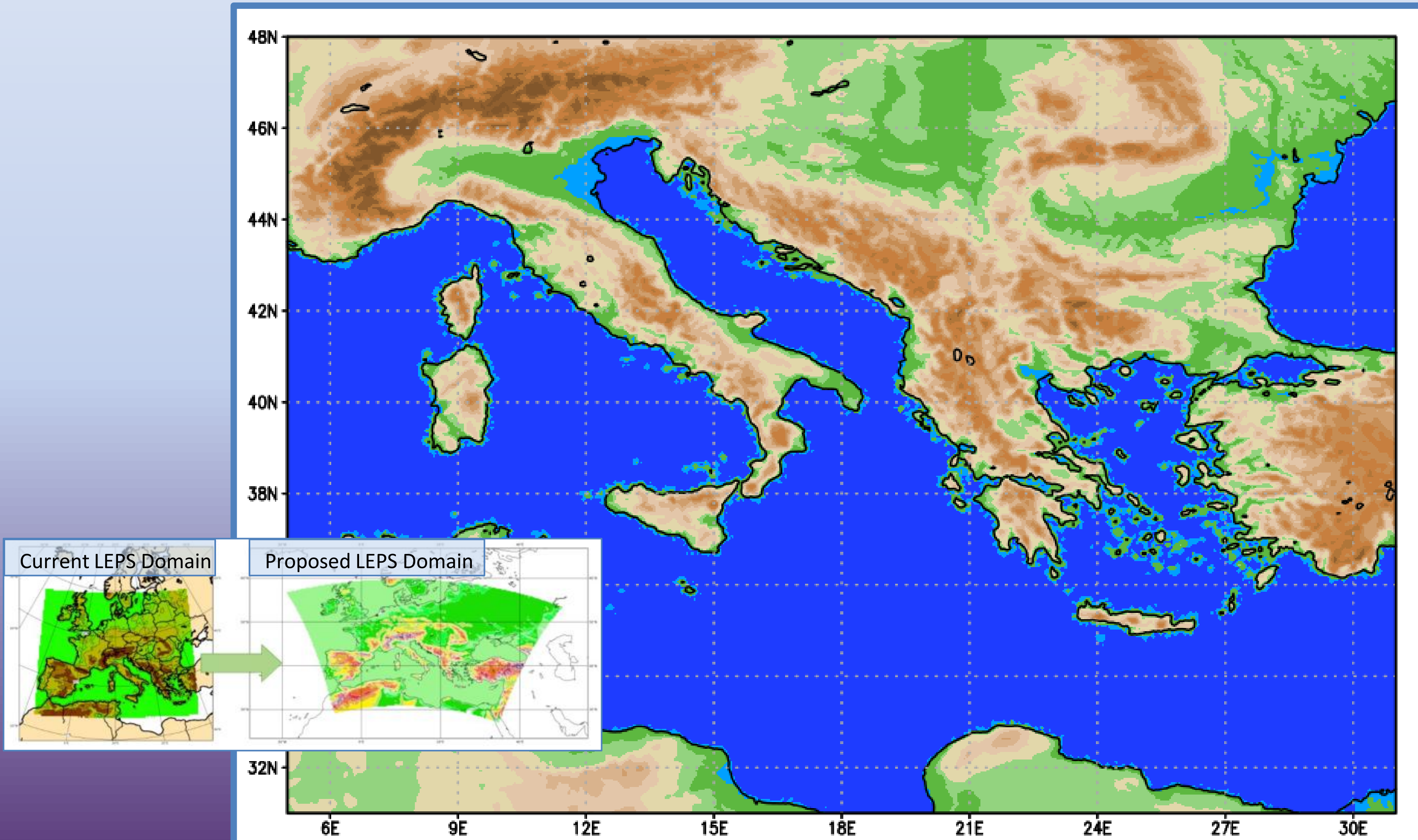
$\otimes$

The evaluation period consisted of the year 2020 (366 days).

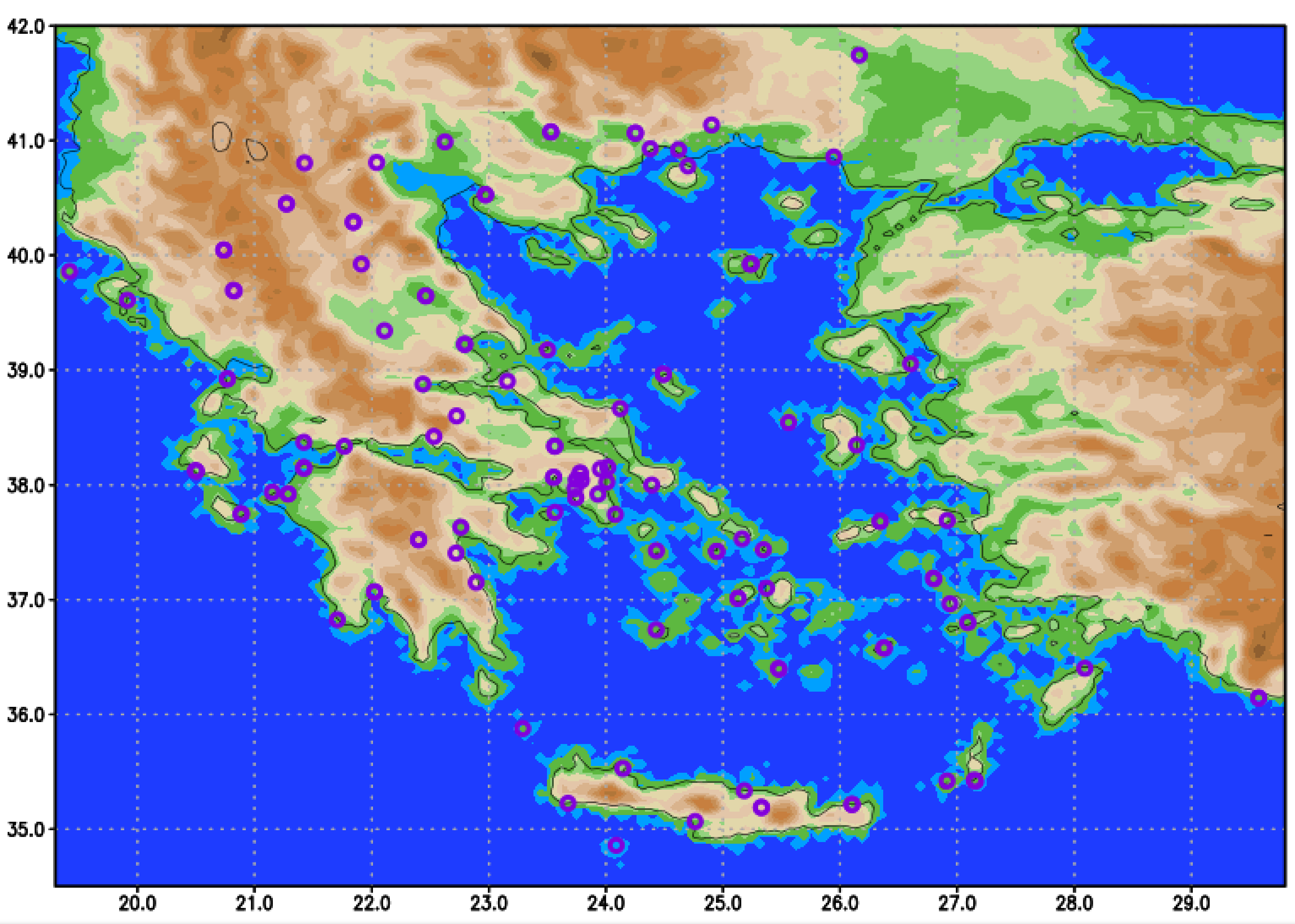
$\approx$

- ~17000 runs based on ICON-IMS.
- Horizontal grid size: R3B08 (~6.5km).
- 417x273 grid points (wider area of Greece and Italy), 65 levels.
- Integration time-step: 60 secs.
- Integration period: 132 hs. (An equivalent period of **two and a half centuries** of model runs)
- Boundary conditions : 3hr IFS Forecast.
- Computational Cost ~ 10^7-10^8 b.u. on Cray X C40 of ECMWF (Gratis HNMS).

Domain under consideration



Station Positions



CONSIDERED PARAMETERS (min,default,max)

- Subscale Orography tunning: Low level wake drag constant for blocking : **gkwake** (1.0 , 1.5, 2.0)

- Grid Scale Microphysics:
  - Terminal fall velocity of ice : **zvz0i** (0.85 , 1,25, 1.45),
  - Raindrop size distribution change : **rain_n0_factor** (0.02 , 0.1, 0.5)

- Cloud Cover:
  - Box width for liquid cloud diagnostic : **box_liq** (0.03, 0.05, 0.07),
  - Liquid cloud diagnostic asymmetry factor - **box_liq_asy** (2.0 , 3.5, 4.0)

- Terra:
  - Evaporating fraction of soil : **c_soil** (0.75, 1.0, 1.25)
  - Scaling for maximum interception storage : **cwimax_ml** ($0.5\text{x}10^{-7}$, $1.0\text{x}10^{-6}$, $0.5\text{x}10^{-4}$)

contd

CONSIDERED PARAMETERS (min,default,max)

- Turbulence:
  - Asymptotic maximal turbulent distance (m) : **tur_len** (250, 300, 350),
  - Normalised supersaturation critical value : **q_crit** (1.6, 2.0, 4.0),
  - Scale for the separated horizontal shear mode : **a_hshr** (0.1, 0.0, 2.0)
  - Stability correction of turbulent length scale factor : **a_stab** (0.0, 0.0, 1.0)
  - Length scale factor for vertical diffusion of TKE : **c_diff** (0.1, 0.2, 0.4)
  - Lower bound of velocity-dependent *Charnock* parameter : **alpha0** (0.0123, 0.0123, 0.0335)
  - Scaling the molecular roughness of water waves : **alpha1** (0.1, 0.5, 0.9)
  - Common scaling for minimum vertical diffusion for heat-moisture and momentum **: tkhmin=tkmmin** (0.55 , 0.75, 0.95)
  - Scaling of laminar boundary layer for heat and Latent and heat fluxes over water (constant product)): **rlam_heat** (and simultaneous change of **rat_sea**) ((0.25,28.0), (1.0,7.0), (4.0,1.75))

contd

CONSIDERED PARAMETERS (min,default,max)

- Convection:
  - Entrainment convection scheme **valid for dx=20km** : **entrorg** (0.00175, 0.00195, 0.00215)
  - Maximum allowed shallow convection depth : **rdephts** (15000, 20000, 25000)
  - Excess value for temperature used in test parcel ascent : **texc** (0.075, 0.125, 0.175)
  - Test parcel ascent excess grid-scale QV fraction : **qexc** (0.0075, 0.0125, 0.0175)
  - Precipitation coefficient conversion of cloud water : **rprcon** (0.00125, 0.0014, 0.00165)
  - Extratropics CAPE diurnal cycle correction : **capdcfac_et** (0.0, 0.5, 1.25)
  - RH threshold for onset of evaporation below cloud base over land : **rhebc_land** (0.80, 0.85, 0.90)
  - RH threshold for onset of evaporation below cloud base over ocean : **rhebc_ocean** (0.70, 0.75, 0.80)

For convenience purposes the following correspondence has been addressed:

a_hshr	**a_stab**	**alpha0**	**alpha1**	**c_diff**	**c_soil**	**capdcfac_et**	**cwimax_ml**	**entrorg**	**gkwake**	**q_crit**	**qexc**
p01	**p02_net**	**p03_net**	**p04**	**p05**	**p06**	**p07**	**p08**	**p09**	**p10**	**p11**	**p12**
rain_n0_factor	**rdepths**	**rhebc_land**	**rhebc_ocean**	**rlam_heat_rat_sea**	**rprcon**	**texc**	**tkhmin_tkmmin**	**box_liq**	**box_liq_asy**	**tur_len**	**zvz0i**
p13	**p14**	**p15**	**p16**	**p17**	**p18**	**p19**	**p20**	**p21**	**p22**	**p23**	**p24**

INVESTIGATED Meteorological FIELDS

<T2m>	2m Temperature [K], 196305 observations , 88 stations
<Tmax2m>	Max 2m Temperature [^{0}C], 15272 observations, 47 stations
<Tmin2m>	Min 2m Temperature [^{0}C], 16037 observations, 47 stations
<Td2m>	Dew point 2 m Temperature [^{0}C], 188218 observations, 88 stations
<tot_prec>	12hr AccumulatedPrecipitation [mm], 32525 observations , 88 stations
<pmsl>	Mean sea level Presure [hPa], 195190 observations, 88 stations
<W10m>	10 m wind intensity [kts], 206469 observations, 88 stations

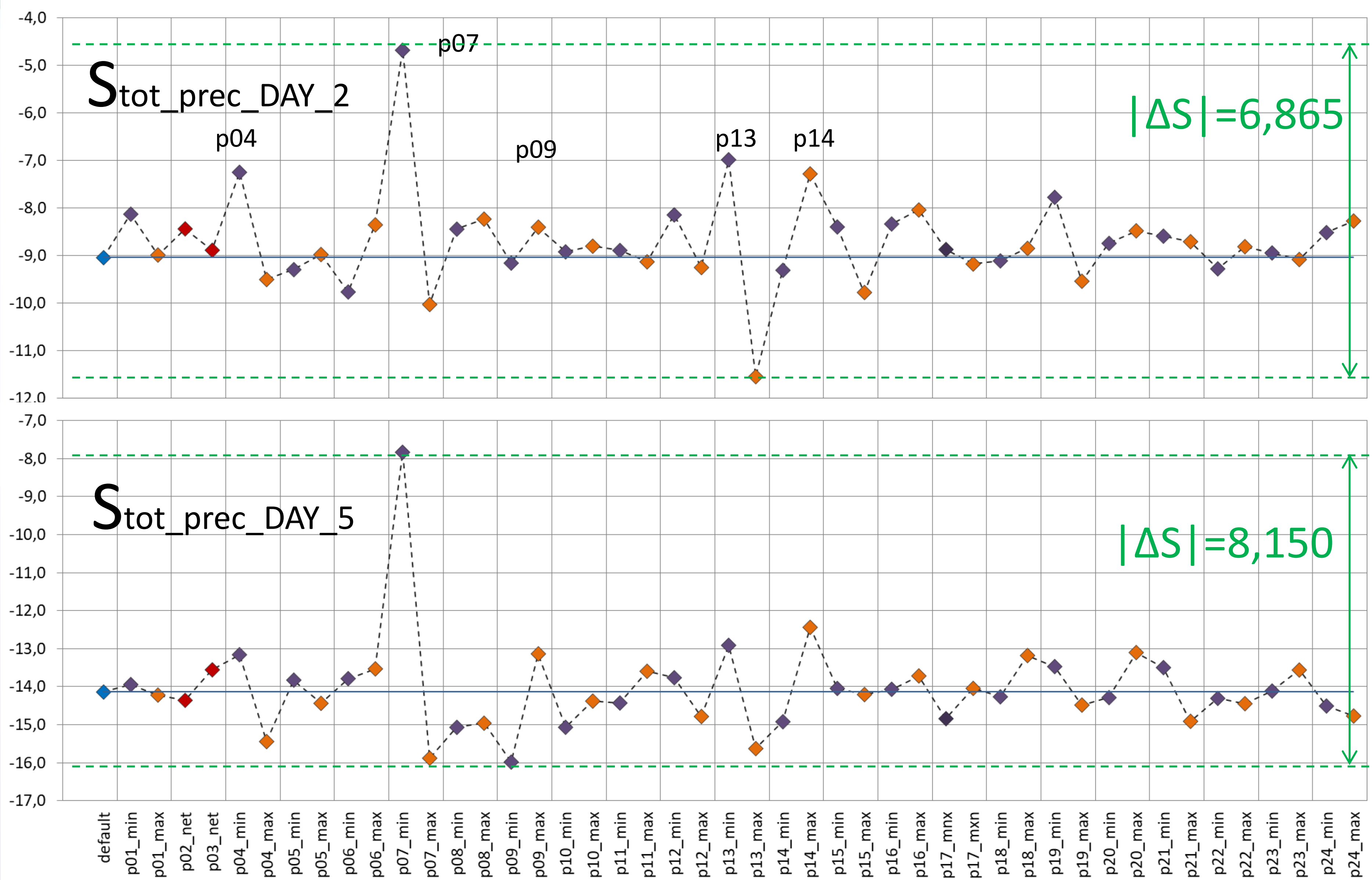
Sensitivity S, Sensitivity Range |ΔS| = |Smax – Smin|

$$S_{P<V>}(\%) = 100 \bullet \left(\frac{<V>_{model}}{<V>_{observe}} - 1 \right)$$

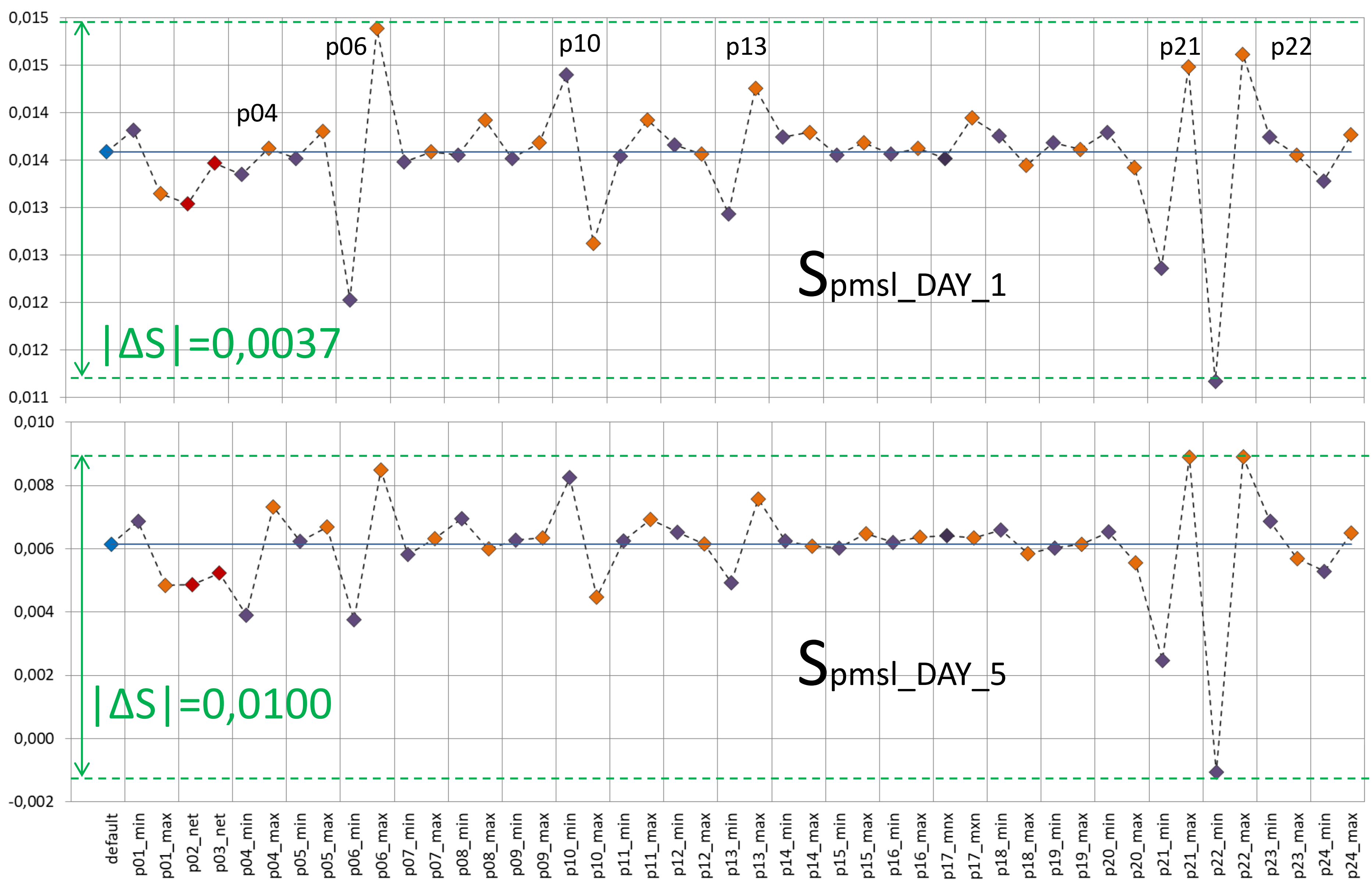
$<V>_{observe}$: Yearly average over all station observations.

$<V>_{model}$: Yearly average over all stations

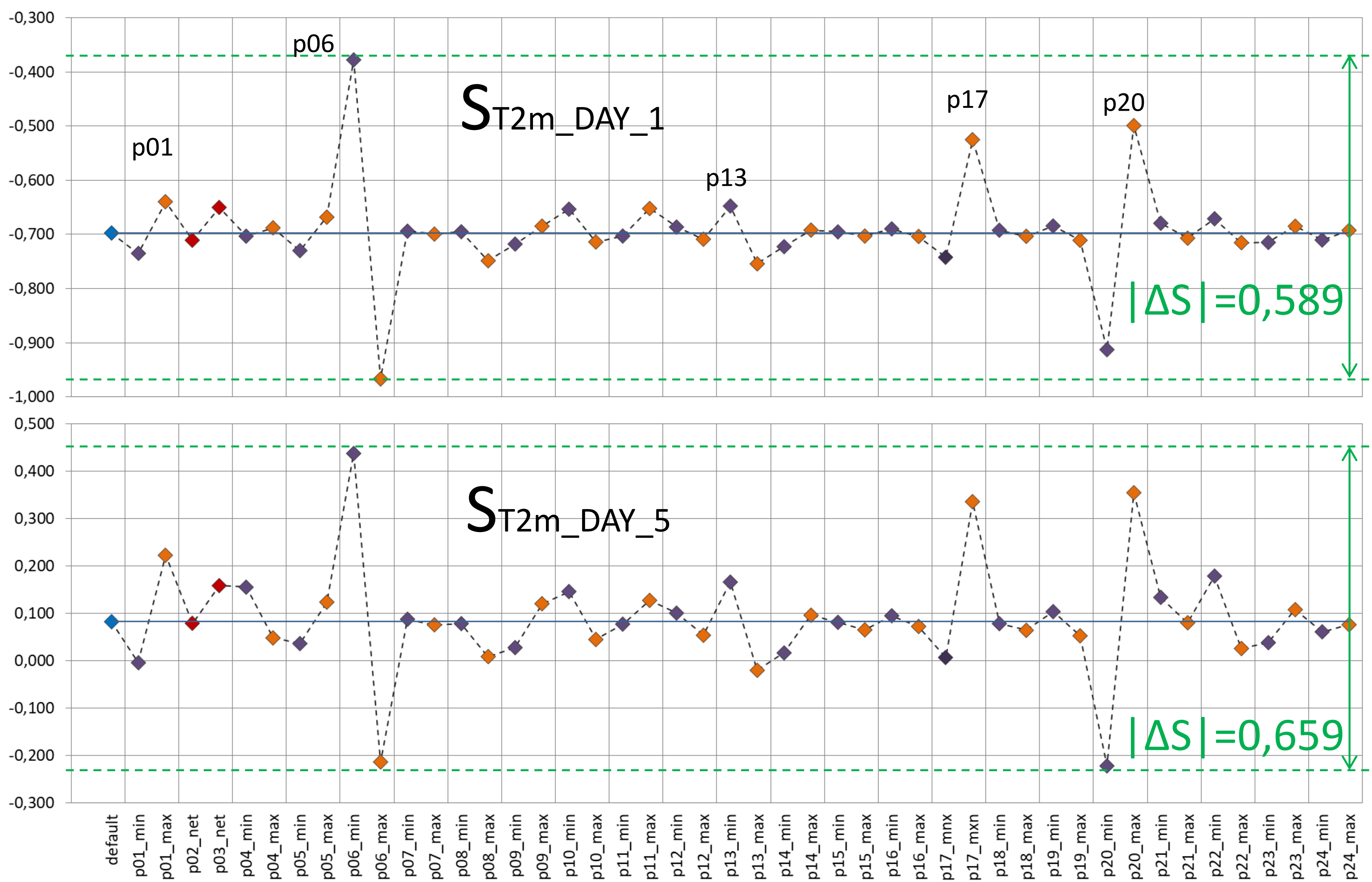
<tot_prec>	12hr AccumulatedPrecipitation [mm], 32525 observations , 88 stations



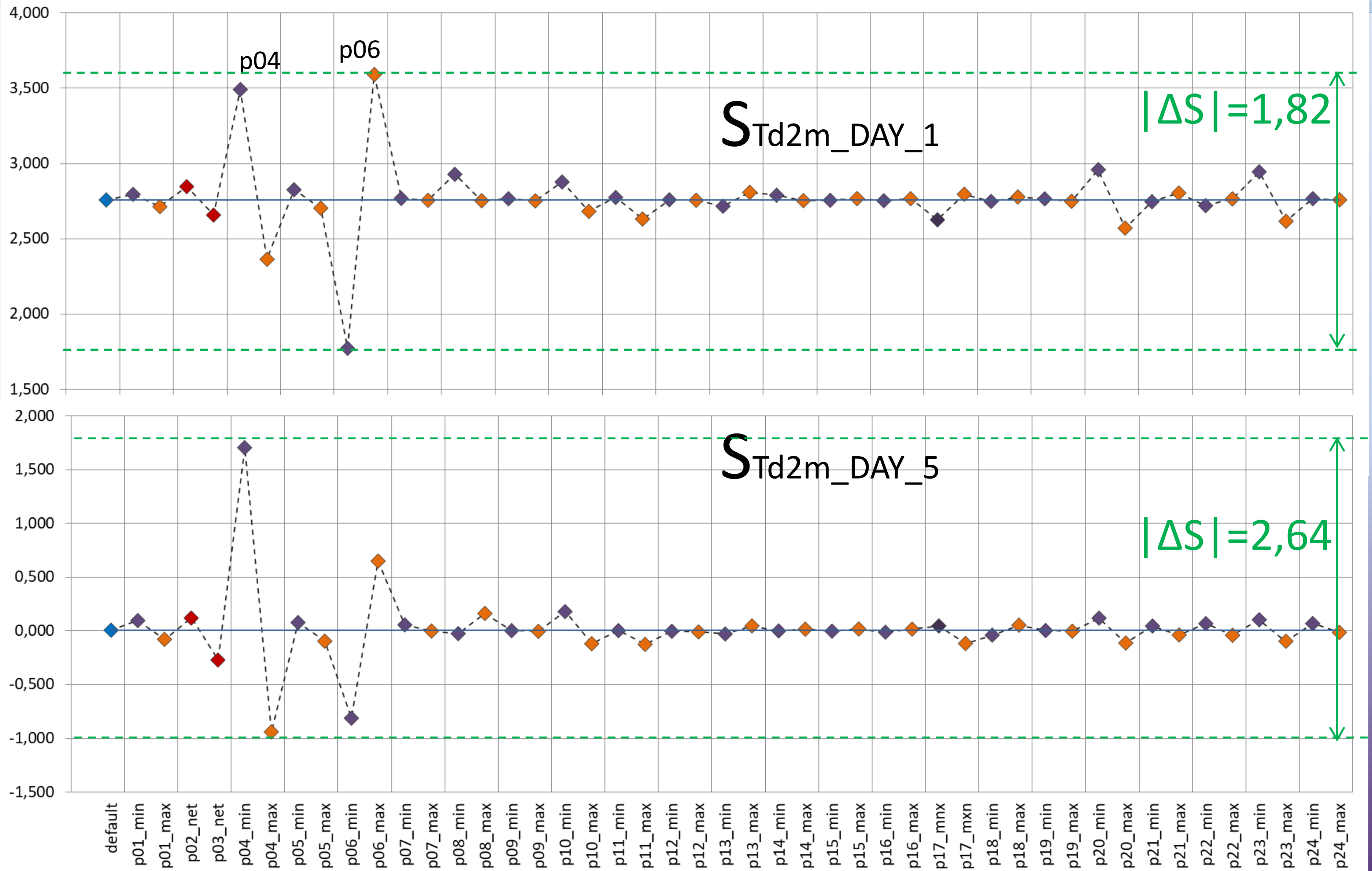
<pmsl>	Mean sea level Presure [hPa], 195190 observations, 88 stations



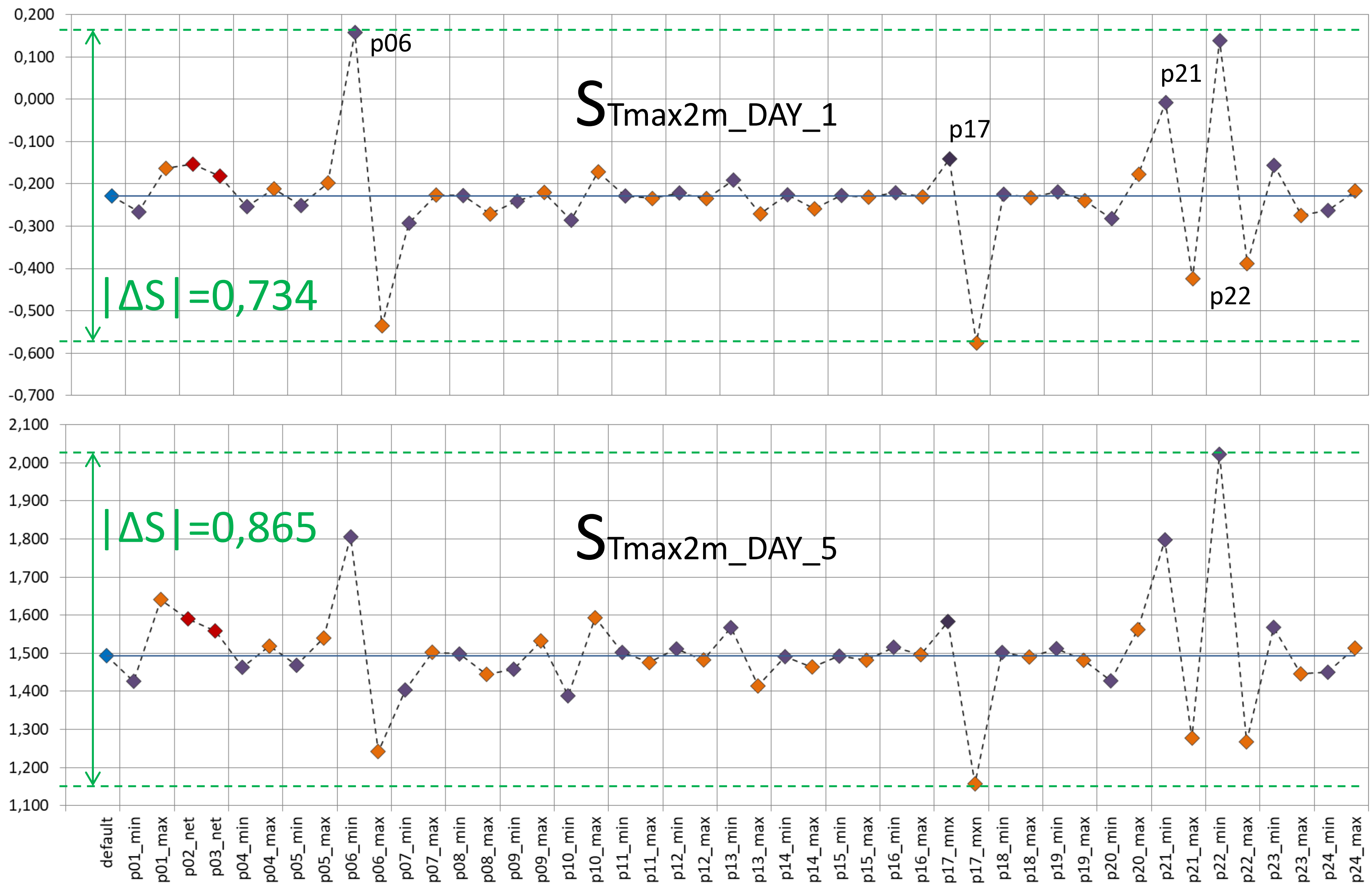
<T2m>	2m Temperature [K], 196305 observations , 88 stations



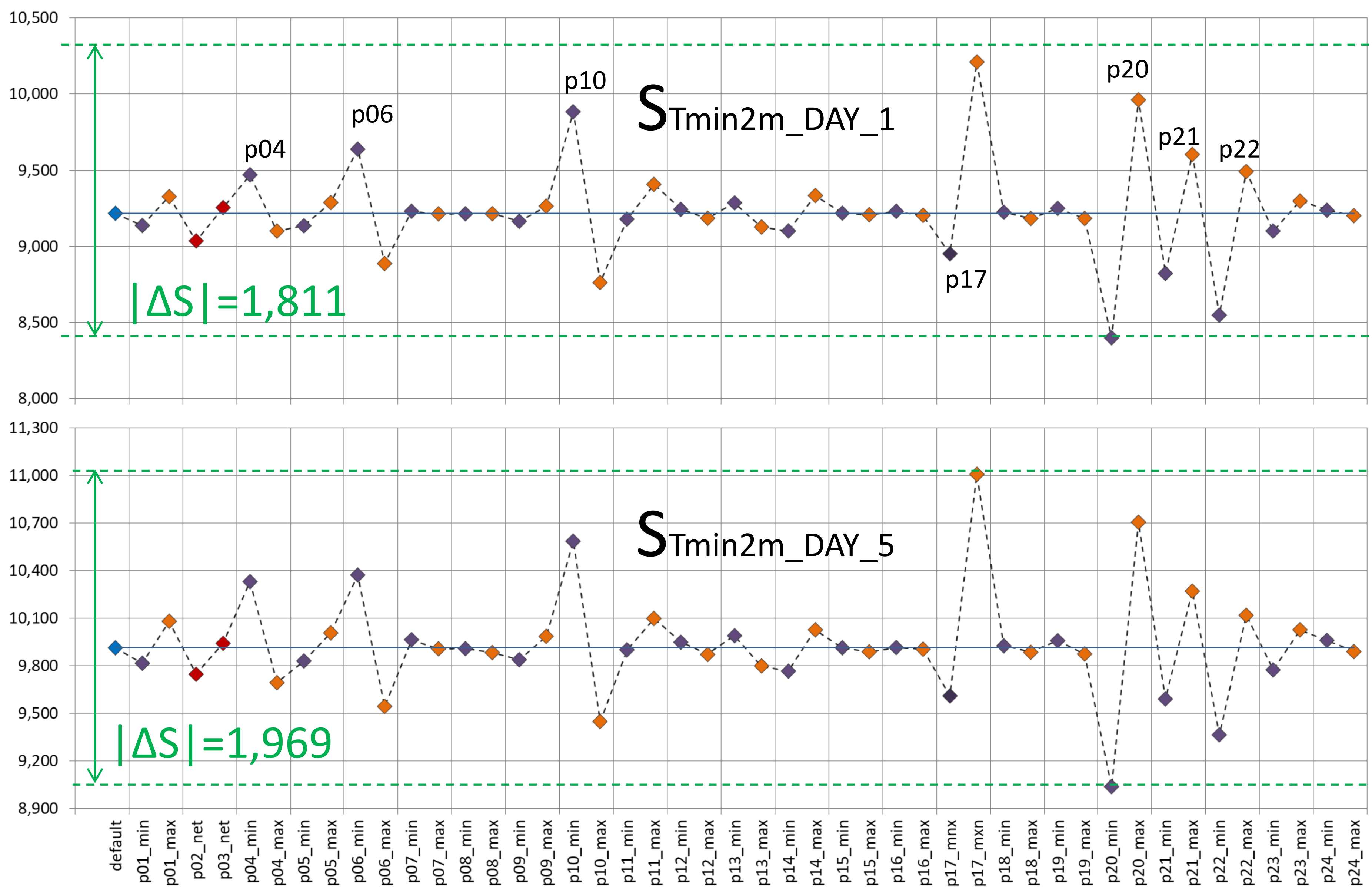
<Td2m>	Dew point 2 m Temperature [^{0}C], 188218 observations, 88 stations



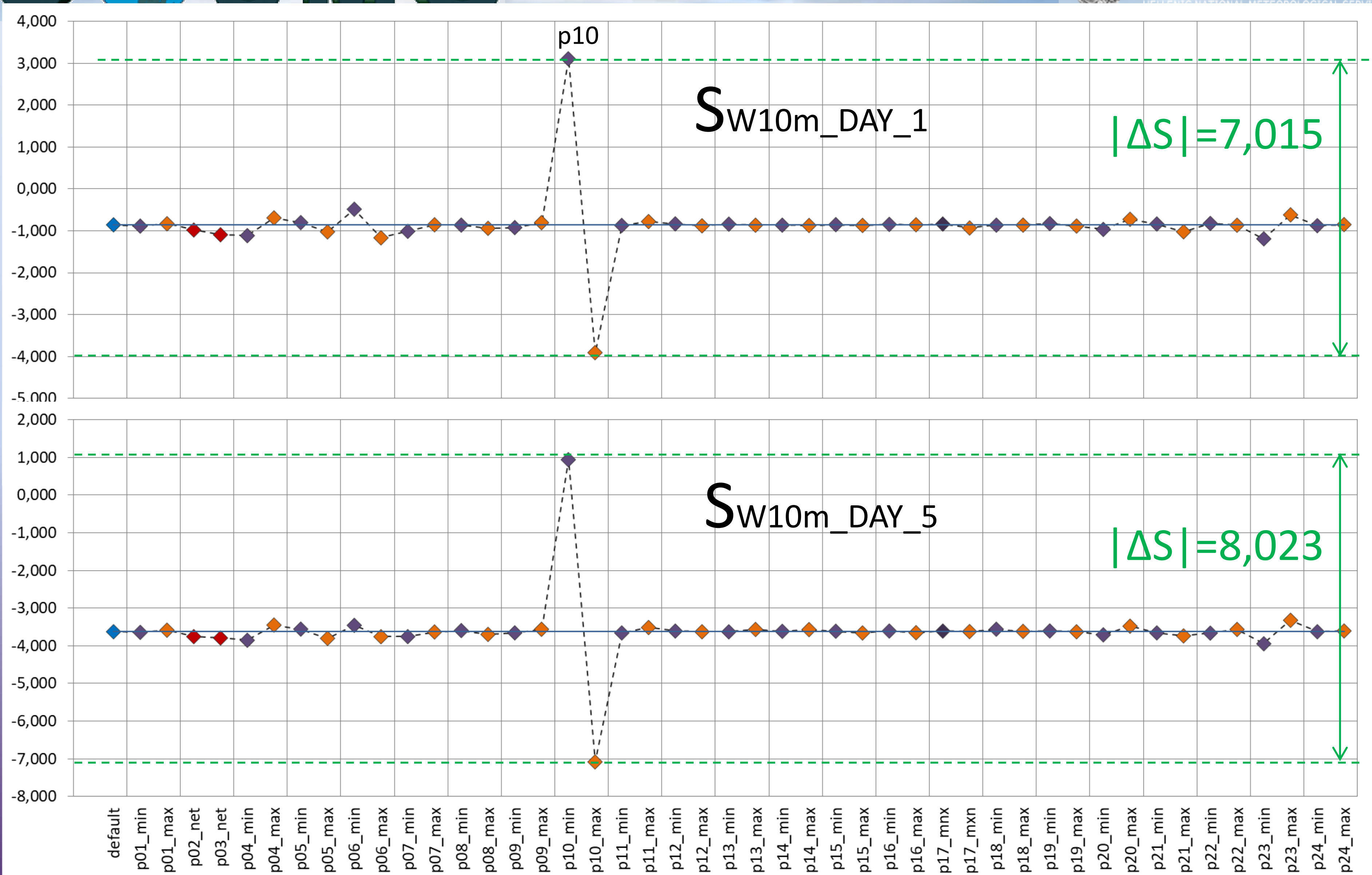
<Tmax2m>	Max 2m Temperature [^{0}C], 15272 observations, 47 stations



<Tmin2m>	Min 2m Temperature [^{0}C], 16037 observations, 47 stations



<W10m>	10 m wind intensity [kts], 206469 observations, 88 stations



Conclusions and prospects:

- The impact for the minimum and maximum values for most of the parameters turned out to be important for the considered meteorological fields, in reference to their default values regarding SYNOP observations over Greece.
- The sensitivity was quite versatile justifying the choice to examine directly a very large number of parameters, probably one of the largest ever in a NWP model. **However a set 7-9 parameters looks like displaying distinguished sensitivity regarding standard meteorological fields i.e. T, TD, PRECI, PMSL and U10M.**
- **These sensitivities look practically independent of the lead time.**
- The advancement towards ICON-LEPS is a formidable operational but also research challenge for the years to come and is expected to have some impact model to ICON model overall.
- Due to the inclusion of a large and complicated marine area in the desired integration domain (i.e. the whole Mediterranean) for the proposed ICON-LEPS, the project is expected to provide significant and lasting advancements in the area of marine meteorology along with additional challenges in NWP in general.

A Note on some References and Visibility :

In addition to the Presentations regarding the progress of this work in COSMO as well as in ICCARUS Meetings within PROPHECY Priority Project, a peer reviewed paper has been submitted in addition to the following publications:

- Avgoustoglou, E; Shtivelman, A.; Khain, P.; Marsigli, C.; Levi, Y; Cerenzia, I. On the Seasonal Sensitivity of ICON Model, COSMO Newsletter, **2023,** 22, 10.5676/dwd pub/nwv/cosmo-nl 22 7. https://www.cosmo-model.org/content/model/documentation/newsLetters/newsLetter22/pg19_sensitivity.pdf
- Avgoustoglou, E; Shtivelman, A.; Khain, P.; Marsigli, C.; Levi, Y; Cerenzia, I. ICON (ICOsahedral Non-hydrostatic) Model Sensitivity over the Central Mediterranean, *Environ. Sci. Proc.* **2023**, *26*(1), 156; https://doi.org/10.3390/environsciproc2023026156

Also, it is considered that Sensitivity of Numerical Weather Prediction Models in general is by itself a very important standalone scientific subject . A Special Issue of « Atmosphere » Peer Reviewed Journal is currently open for submissions:

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- resolution
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that make this work possible

and hopefully its further proggress !