SPECIAL PROJECT PROGRESS REPORT

All the following mandatory information needs to be provided. The length should *reflect the complexity and duration* of the project.

Reporting year	………………2020/2021………………….……
Project Title:	Improvement of very-short term forecast using lightning and radar data assimilation ………………………………………….……
Computer Project Account:	SPITFEDE……………………………….……
Principal Investigator(s):	Stefano Federico……… ……………………………………………….……
Affiliation:	……CNR-ISAC……………….……
Name of ECMWF scientist(s) collaborating to the project (if applicable)	…………………………….…… ……………………………………………….……
Start date of the project:	1 January 2021…………….……
Expected end date:	31 December 2023…………….……

Computer resources allocated/used for the current year and the previous one

(if applicable)

Please answer for all project resources

		Previous year		**Current year**	
		Allocated	Used	Allocated	Used
High Performance Computing Facility	(units)	/	/	20000000	7500000
Data storage capacity	(Gbytes)	/	/	35TB	29TB

Summary of project objectives (10 lines max)

The general objective of the project is to evaluate the impact of data assimilation on the very-short term forecast over Italy, with emphasis on high precipitation events. This objective is huge and must be focused on specific goals that can be tackled in the framework of this special project.
For this project the data assimilation is focused on lightning and radar reflectivity data, even if some additional data taken from SENTINEL satellites will be explored, while the verification is mainly on precipitation forecast. Some additional parameters, as surface winds, could be also considered for verification.

Summary of problems encountered (10 lines max)

No significant problems were encountered working on this project and the ECMWF assistance solved all problems efficiently. The disk quota of 35 TB is almost full and, in the following months I will ask for an extension of this quota because there are several datasets to be saved and the initial request of 35TB was underestimated. If no additional space will be allocated on ECFS, I will transfer part of the data to other computers, to free space for new datasets.

Summary of plans for the continuation of the project (10 lines max)

The future plans for the project for the current year and for the first part of the second year are the following: first to perform a numerical experiment for a period of 10 days of October 2019 (already ongoing), characterised by several convective events over Italy, to have a first evaluation of the impact of lightning data assimilation (LDA) on the precipitation forecast at the short-term with WRF model. Second, to evaluate the impact of two different techniques to assimilate lightning, 3D-Var and nudging, on the performance of WRF for the short-term precipitation forecast. Third, to evaluate the impact of LDA used together with radar data assimilation on the precipitation forecast at the short-term. Fourth, to suppress spurious convection through LDA will be considered. Numerical experiments are focuses over Italy and are made at 3 km horizontal resolution and with 50 vertical levels. The program for part of the second years and for the third year of the project, including the assimilation of SENTINEL data, will depend on the results of these experiments.

List of publications/reports from the project with complete references

No publications have been done for this project because it started 6 months ago. I have submitted a paper, with several colleagues, considering a heavy precipitation event occurred over Palermo, the most populated city of Sicily. The paper was submitted on the special issue of the journal "Atmosphere" entitled "Numerical Modeling and Statistical Analysis of Severe Weather Conditions and Extreme Events". The web page of the special issue is: https://www.mdpi.com/journal/atmosphere/special_issues/Severe_Weathe_Events and the paper is under review.

Summary of results

During this project I will switch from the RAMS@ISAC model, that was used for several years on cca to study lightning data assimilation, to WRF model with lightning data assimilation (both through nudging and 3D-Var). In the first six months of this Special project, I installed a copy of WRF model on cca. The model is version 4.1 and differs from that installed on cca for the specific part of lightning data assimilation, which is widely used in this project. As an aside activity, with the help of ECMWF staff, I installed a copy of WRF also on TEMS. The model was run successfully on both machines.
A numerical experiment with WRF was just started to assess the impact of lightning for a period of 10 days on October 2019 over Italy, characterised by several convective events. In this experiment two different techniques to assimilate lightning will be compared: nudging and 3D-Var.
However, the SBU of the first six-months of the project was used mainly to study a deep convective case study occurred over Palermo on 15/07/2020. The event was localised in space and time and was

forced by the destabilisation of the planetary boundary layers in a large-scale environment favourable to convection development. Figure 1 shows the rainfall observed between 14 and 17 UTC.
Thunderstorms were active in several parts of Sicily and over the Italian peninsula with rainfall up to 30-40 mm/3h; these events are typical of hot summer days, when large scale conditions favour the convection development and the land, warmed by the intense solar radiation, acts as a trigger. Palermo shows the largest precipitation amounts (> 100 mm/3h) with very localised rainfall.

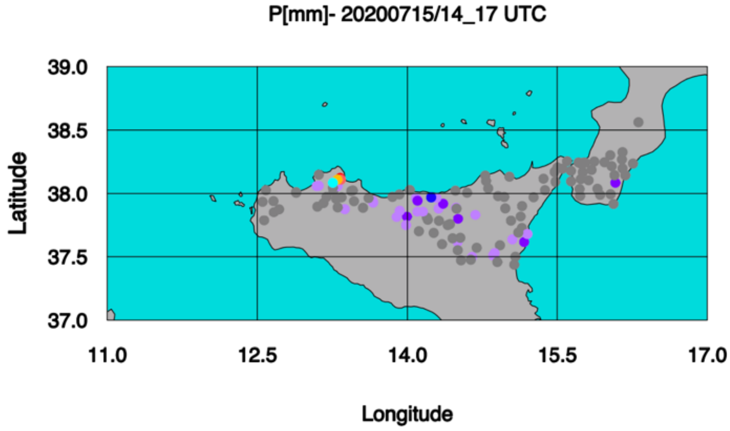

Figure 1: Observed precipitation between 14:00 and 17:00 UTC on 15 July 2020 for Sicily and part of Calabria, southern Italy. The raingauge network belongs to the Italian regional administrations, whereas the data are collected nationwide by the Department of Civil Protection.

Lightning and radar reflectivity data assimilation were very important for this event. Indeed, the control forecast, without radar or lightning data assimilation predicted rainfall over the eastern part of Sicily but missed the event in Palermo.
Lightning data assimilation was fundamental to trigger precipitation over Palermo and the localisation of the event was very precise in space and time. The run with lightning data assimilation forecast 55 mm/3h over Palermo and, while the precipitation forecast was only half of that observed, lightning data assimilation was able to trigger an intense convective event over the city.
Radar observations over Sicily were not available for this case study, and the radar data assimilation alone did not influence the rainfall forecast over Palermo. Nevertheless, also the radar data assimilation had an important impact on the precipitation forecast of the Palermo case, when used with lightning data assimilation. In fact, the assimilation of the reflectivity of the Mnt. Armidda radar (in Sardinia island), increased the water vapour amount between Sicily and Sardinia. This water vapour addition reinforced and sustained the convection triggered by lightning data assimilation, increasing the rainfall forecast over Palermo from 55 mm/3h, when only lightning data assimilation is applied, to 90 mm/3h, when both lightning and radar reflectivity data assimilation is applied.
While the forecasts with radar and lightning data assimilation could have been useful for the management of the event, the results demonstrate the need to refine the possible operational forecasting tools, for example through rapid update forecast cycles (30 min – 1h) with data assimilation at the local scale, to better manage deep convective summer events over Italy.
As stated in the "List of publications section" a paper on this case study has been submitted on the journal Atmosphere.